MODERN PLASTICS

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OCTOBER 1942

The Robot that had its face lifted

WHEN OUR ARSENALS needed aluminum . . . this genius robot cheerfully underwent a bit of plastic surgery.

But don't get robot wrong. It isn't trying to imply that it's winning the war single-handed just because it gave up its aluminum. It doesn't even want to brag about how it can add, subtract, multiply or divide . . . at the punch of a key. Robot merely wants Mr. Streng to tell you about its operation . . .

"When Remington Rand Inc. asked me to develop a new housing for their calculator, I found the perfect solution to the problem in Durez phenolic plastics.

"To begin with, they are extremely strong and durable yet light in weight. Because even complicated forms can be precision molded in one operation . . . plastics permit economical mass production. And in this particular case, Durez phenolic plastics brought two new advantages to the machine: less noise and less glare. Being non-reverberating, the plastic does not transmit the noise set up by the machine in operation. The wrinkles you see in the housing eliminate the glare refracted by the lustrous surface of conventional machines. This feature reduces the eye-strain so familiar to calculator operators. But that's not all the story. This Durez housing is so designed, it fits over Remington's adding machine as well as their calculator. Now one mold does two jobs!"

JAN STRENG,
Industrial Designer

To designers and engineers this particular success story of Durez phenolic plastics and resins follows a familiar pattern. Further, it foreshadows the vital position that plastics will take in developing our post-war economy. Plastics have a versatility unequaled by any other man-made material. New uses open up for them every day. They are proving themselves in war, too. So well, perhaps they can give *your* production lines a lift. Write today on your business letterhead for a copy of *Durez Plastics News.*

DUREZ...plastics that fit the job

DUREZ PLASTICS & CHEMICALS, INC. DUREZ 1130 WALCK ROAD, N. TONAWANDA, N. Y.

The First Truly RUBBER-like Plastic

. . . with challenging post-war possibilities!

THIS soldier's girl will have to wait until after victory is won. But once expansion of production facilities is possible, the plastic that replaces rubber in this soldier's G.I. Raincoat has possibilities that may affect her living—and your business—in a score of interesting ways.

The plastic is Monsanto's Saflex, originally developed from the family of synthetic resins known as vinyl acetals to serve as a tough, resilient interlayer in high test safety glass.

Now, thanks to recent advances in its formulation, Saflex qualifies as the first truly rubber-like plastic and it can be supplied in thermoplastic or thermosetting forms . . . can be vulcanized and otherwise handled much like rubber . . . can be extruded into threads, tubes, or sheets . . . molded by compression or injection . . . or applied to fabrics by calendering or spreading all with equal facility.

At present, all available Saflex will be required for vital military needs. It is already replacing rubber in Army rain coats, Marine Corps water bags, Chemical Warfare gas protective curtains and a surprising list of military items formerly made from rubberized fabric. Molded heels of both thermosetting and thermoplastic Saflex are being field tested on several thousand pairs of Army shoes, where they promise to outwear leather and reclaimed rubber. Extruded tubing has been approved for Civilian Defense stirrup pump hose.

What the availability of materials as promising and versatile as the new Saflex compounds will mean in post-war years is anyone's guess. This much is certain, however, *you will be hearing and seeing more and more of Saflex as a key factor in post-war plans for industrial products and consumer goods alike!* MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield, Mass.

MONSANTO PLASTICS

SERVING INDUSTRY . . . WHICH SERVES MANKIND

THE FAMILY OF SIX MONSANTO PLASTICS

(Trade names designate Monsanto's exclusive formulations of these basic plastic materials)

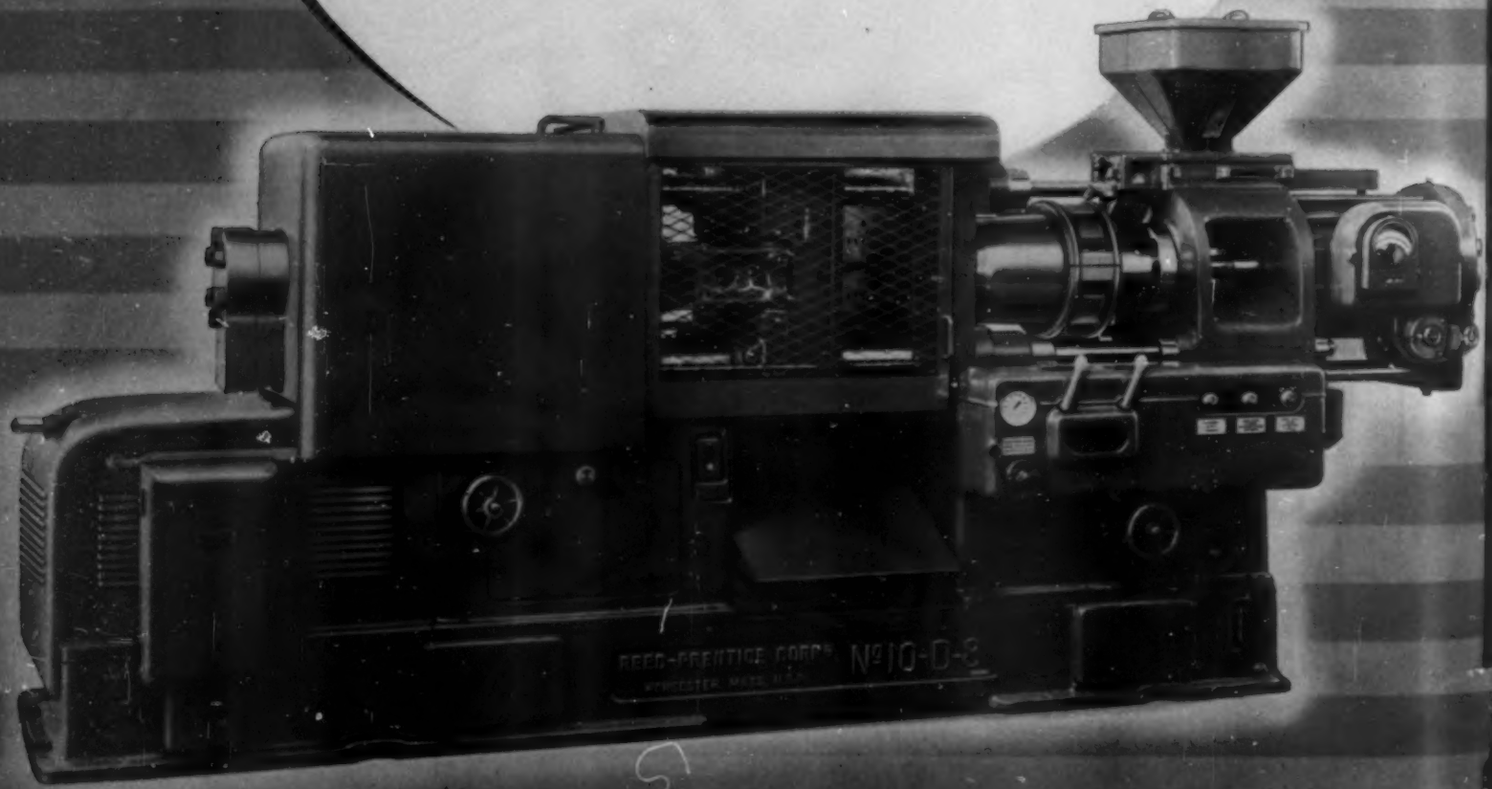
LUSTRON (polystyrene) • **OPALON** (cast phenolic resin)
FIBESTOS (cellulose acetate) • **NITRON** (cellulose nitrate)
SAFLEX (vinyl acetal) • **RESINOX** (phenolic compounds)

Sheets • Rods • Tubes • Molding Compounds • Castings
Vuepak Rigid Transparent Packaging Materials

Reed-Prentice Plastic Injection Molding Machines are precision tools designed to provide large quantities of molded parts where speed and the saving of essential material are paramount.

At this time, when continuous, uninterrupted production is a prime requirement, Reed-Prentice machines are the choice of those molders who are looking for dependability as well as versatility.

Reed-Prentice machines are manufactured in four, six, and eight ounce capacities. Our engineers will be glad to co-operate in selecting the machine which will be most efficient and economical to operate depending upon your individual requirements.



REED-PRENTICE CORPORATION 1213 W. 3d St., CLEVELAND, OHIO
75 WEST ST., NEW YORK CITY
WORCESTER, MASSACHUSETTS, U.S.A.

modern plastics

INCLUDING

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It used to take days to make these of [redacted]

THESE queer-looking plastic shapes are serving the armed forces. We're sorry we can't tell you what they are for—but this is war.

Nevertheless, they are a good example of the way INSUROK is being used to help solve the difficult problem of giving the boys *more and better* equipment with which to win.

In countless ways INSUROK and The Richardson Company's "know how" have shortened the time from blueprint to production, to increase output per machine-hour and to provide more latitude for designers with imagination.

There are many ways in which INSUROK precision plastics and the experienced *Richardson Plasticians* can save vital time and effort for war products producers. If you have a problem which experience in producing and working with molded and laminated plastics might solve, write us. We'll be glad to give you the benefit of our research knowledge and facilities.

The Richardson Company, Melrose Park, Ill.; Lockland, Ohio; New Brunswick, N. J.; Indianapolis, Ind. Sales Offices: 75 West St., New York City; G. M. Building, Detroit.

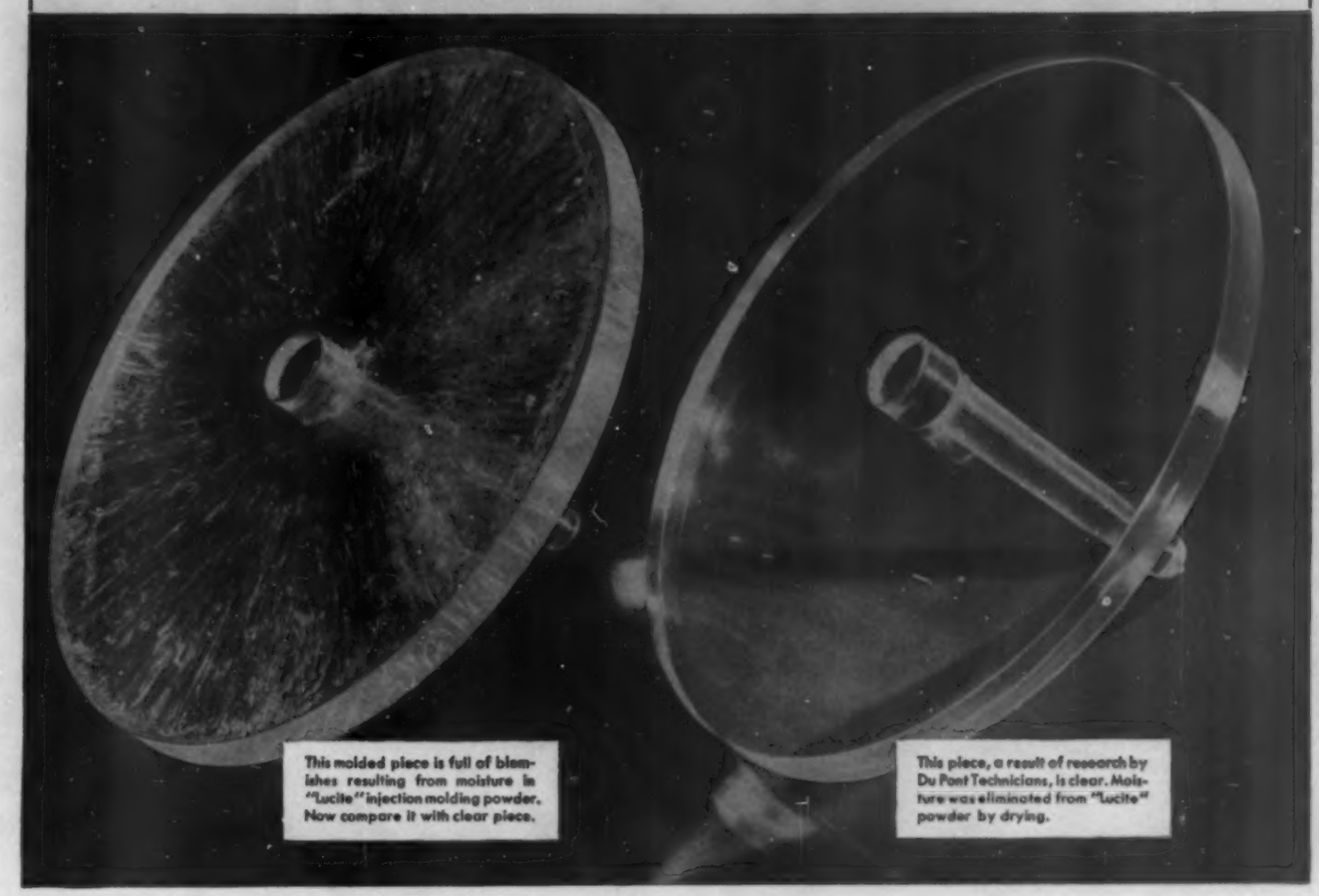
INSUROK *and the experience of Richardson Plasticians are helping war products producers by:*

1. Increasing output per machine-hour.
2. Shortening time from blueprint to production.
3. Facilitating sub-contracting.
4. Saving other critical materials for other important jobs.
5. Providing greater latitude for designers.
6. Doing things that "can't be done."
7. Aiding in improved machine and product performance.

INSUROK

MADE AND SOLD ONLY BY THE RICHARDSON COMPANY

HOW TO DRY "TEAR DROPS" IN MOLDED PLASTICS


This molded piece is full of blemishes resulting from moisture in "Lucite" injection molding powder. Now compare it with clear piece.
This piece, a result of research by Du Pont Technicians, is clear. Moisture was eliminated from "Lucite" powder by drying.

Using heat to remove moisture from molding powder, Du Pont Plastics Technicians find another way to take the guesswork out of molding Du Pont plastics

WHY do tear-drop surface blemishes and bubbles appear in heavy molded sections like the one above? Du Pont Plastics Technicians have researched to find the cause and solution.

This investigation showed that moisture in the atmosphere was sabotaging injection molded pieces. Most thermoplastic molding powders are hydroscopic. Molding powder may be dry before leaving the plant in which it is made. But during shipment and storage it picks up moisture. The more humid the day, the more moisture the powder absorbs.

Du Pont's study discovered that moisture in "Lucite" methyl methacrylate resin powders causes tear-drop and bubble blemishes in heavy sections.

What to do about moisture? The answer is "drive it out." Drying results in elimination of blemishes in the molded pieces, just as preheating of compression molding powder eliminates white steam specks in the finished pieces molded of Du Pont plastics. In addition, when "Lucite" is used immediately after preheating, the residual heat in the powder helps to reduce the molding cycle.

There are two good methods of drying Du Pont injection molding powders. Infra-red lamps are the fastest and cleanest. Hot air ovens or electric convection ovens, however, are more economical for large production.

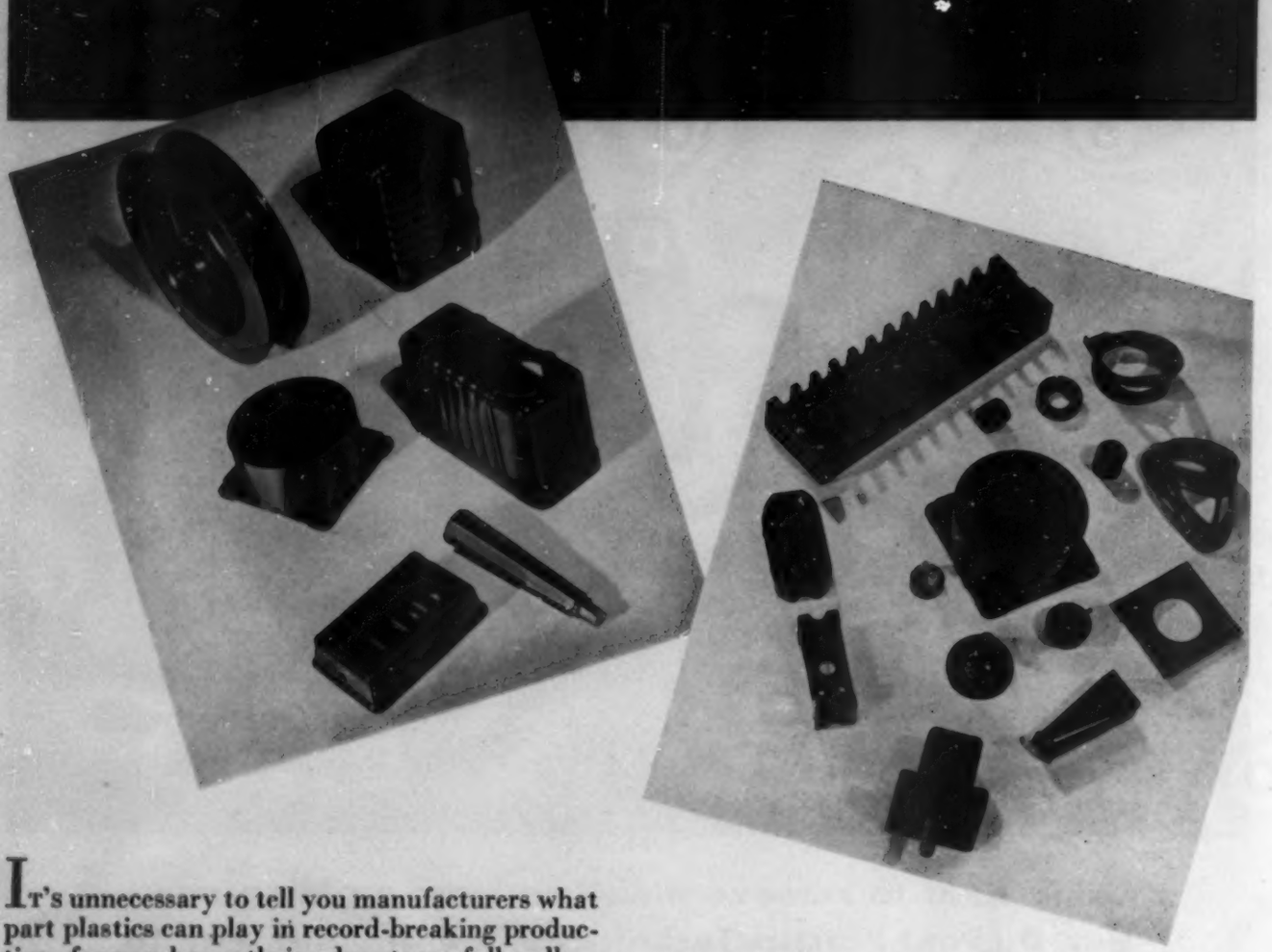
Du Pont Technicians are constantly working to take the guesswork out of molding plastics. They are looking for new molding techniques. They are actively aiding molders, fabricators, designers and users, in making the best use of "Lucite," "Plastacele" and "Pyralin," cellulose nitrate plastic. Today, of course, this skill is devoted mostly to production for war service. We will be glad to help you if you need us. Write E. I. du Pont de Nemours & Co. (Inc.), Plastics Department M, Arlington, New Jersey.

DU PONT

PLASTICS

Better Things for Better Living
. . . *Through Chemistry*

HOW PRECISE PLASTIC PARTS CAN SPEED YOUR PRODUCTION



It's unnecessary to tell you manufacturers what part plastics can play in record-breaking production, for you know their advantages full well.

But what should be emphasized is that *precise* plastic parts can greatly speed your output by reducing inspection rejects and by eliminating the need either for "forcing" parts to fit or searching for a part that fits.

Auburn molded plastic parts have been made always to a high standard of accuracy—finishing is thorough, inspection especially keen, handling and packing most carefully done.

While this type of exacting workmanship may seem more expensive initially, actually in the long run it is less because of savings in assembly time and improved quality.

Since 1876 we have been molding to the same high standard for it's the only standard we know how to meet—it's the standard that helps you most.

AUBURN BUTTON WORKS, INC.

ESTABLISHED 1876

AUBURN, NEW YORK

MOLDERS OF ALL TYPES OF PLASTIC MATERIALS BY COMPRESSION, TRANSFER INJECTION AND EXTRUSION METHODS

ANNOUNCEMENT TO THOSE MEN IN

PRODUCTION AND RESEARCH

TO WHOM THE

STRESS-STRAIN DIAGRAM IS A WORKING ESSENTIAL

A thorough knowledge of material characteristics is playing an increasingly important part in production and research testing. In the never-ending search for better materials, substitute materials, greater production speed, higher safe working loads, etc., the Olsen Electronic High Magnification Recorder is an accepted part of testing procedure.

This sensitive extensometer-recorder used in conjunction with an Olsen Universal Testing Machine sets down on one chart the complete cumulative history of any test—from beginning to end. The unique Sivertsen System employed was developed in the Olsen engineering department and features among other items: extreme simplicity of operation, high accuracy of the chart recording, versatility of use, and a background of over six years' successful operation in many of the leading plants in the country.

If you can put the stress-strain diagram to work on your production line or in your laboratory, then Bulletin 24 should prove of real interest. Send today for your copy.

Send today for your copy of **Bulletin 24** The Olsen High Magnification Recorder

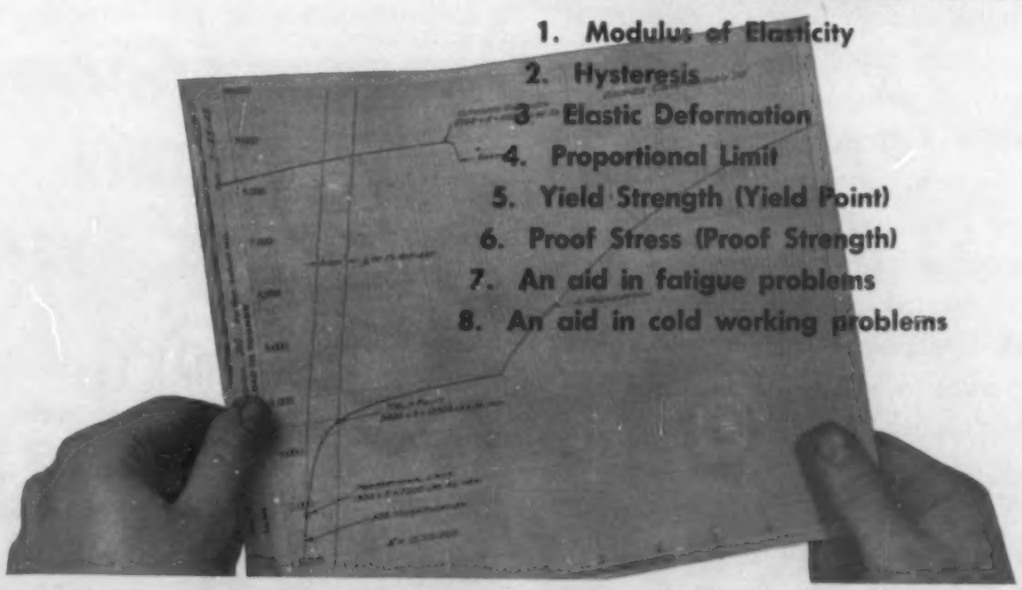
Proving every day that the value of testing depends on the quality of the testing equipment.

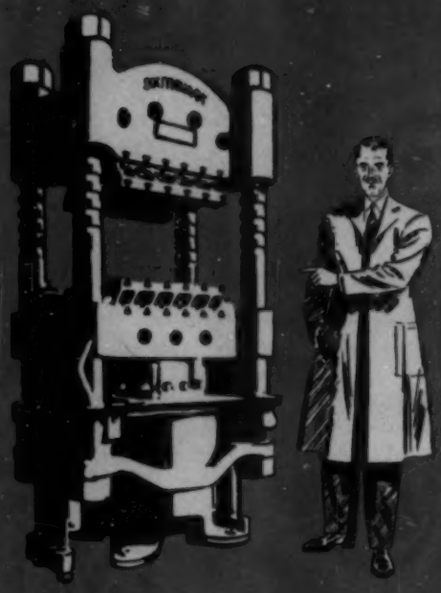
TINIUS OLSEN TESTING MACHINE CO.
580 NORTH TWELFTH STREET, PHILADELPHIA, PA.

Western Representative
PACIFIC SCIENTIFIC COMPANY
Los Angeles, San Francisco, Seattle

A STRESS-STRAIN DIAGRAM PUTS THESE FACTS AT YOUR FINGER TIPS!

1. Modulus of Elasticity
2. Hysteresis
3. Elastic Deformation
4. Proportional Limit
5. Yield Strength (Yield Point)
6. Proof Stress (Proof Strength)
7. An aid in fatigue problems
8. An aid in cold working problems





for

stronger,

LARGER

molded pieces

. . . . install Southwark Hydraulic Presses

Increased requirements for molded articles call for presses *rugged* enough to stand production demands placed upon them, *accurate* in performance to maintain highest quality, and economical in operation and maintenance so that unit cost can be kept low. To meet these demands, Southwark engineers have developed powerful presses for molding stronger and larger pieces.

The press illustrated is but one of many types of Southwark hydraulic steam platen presses engineered to meet today's requirements in rubber and plastics manufacture. When you're planning new plant equipment for the competition of tomorrow it will pay you to specify Southwark.

Southwark hydraulic molding presses have proven their reliability, have shown the way to reduced production costs, have helped many a company do a better job—more economically.

BALDWIN

Southwark

BLW THE BALDWIN GROUP

DIVISION OF THE BALDWIN LOCOMOTIVE WORKS • PHILADELPHIA

Use of Power Tools • Speedier Driving • No Slipping = 50% Less Assembly Time with Phillips Screws

Here's a way you can prove to yourself that Phillips Recessed Head Screws are "fast as greased lightning."

Check up on how many assemblies your crew handles in a day, using slotted screws. Then—give them a day's supply of Phillips Screws. Even without a change in *driving* method, production will go up. And since Phillips Screws end driver slippage, they can use power tools—with the result (on the average) that they can *double* their output.

You will *eliminate wasted effort* because the Phillips Screw clings to the driver; *prevent lost-time accidents* because screwdriver injuries are no more; and *get stronger fastenings* because Phillips Screws seat tight without heads splitting. In addition you save an average of 50% in *cost* as well as time.

Any of the firms listed below can supply you

PHILLIPS RECESSED HEAD SCREWS

GIVE YOU *2 for 1* **(SPEED AT LOWER COST)**

WOOD SCREWS • MACHINE SCREWS • SHEET METAL SCREWS • STOVE BOLTS • SPECIAL THREAD-CUTTING SCREWS • SCREWS WITH LOCK WASHERS

American Screw Co., Providence, R. I.
The Bristol Co., Waterbury, Conn.
Central Screw Co., Chicago, Ill.
Chandler Products Corp., Cleveland, Ohio
Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
The Charles Parker Co., Meriden, Conn.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterbury, Conn.
Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
Whitney Screw Corp., Nashua, N. H.

In a Change-over to *Plastics*

—YOU CAN SOLVE YOUR FASTENING PROBLEMS SIMPLY AND QUICKLY!

Call in a Parker-Kalon Assembly Engineer!

When you start "ironing out" the assembly problems in your change-over to plastics, *Parker-Kalon can help you!* Parker-Kalon Assembly Engineers have shown you how to *save time and labor* on all types of metal assembly with Self-tapping Screws – AND, their knowledge and experience *with plastics* will be just as valuable to you.

They can show you how the right type of Parker-Kalon Self-tapping Screw can make fastenings to plastics quicker and easier than by any other fastening method. They can help you put P-K Screws to work on your assembly line without costly delays – for, no skilled hands or special tools are required. Get the *most* out of your switch to plastics – call in a Parker-Kalon Assembly Engineer, now! Write Parker-Kalon Corporation, 190-200 Varick Street, New York, N. Y.

A TYPE FOR EVERY METAL OR PLASTIC ASSEMBLY

There's a P-K Self-tapping Screw for Every Type of Plastic Assembly

Whether your particular job requires a *thread-cutting* or *thread-forming* screw, there's a P-K Self-tapping Screw that will speed up your assembly by eliminating tapping operations or the use of tapped inserts. And, the correct type of P-K Screw will give you a BETTER as well as cheaper means of assembly. Remember, too, that the Parker-Kalon Quality-Control Laboratory – without counterpart in the screw-making industry – assures consistently reliable performance. "Doubtful screws" – screws that *look* all right but some of which fail to *work* right – are eliminated.

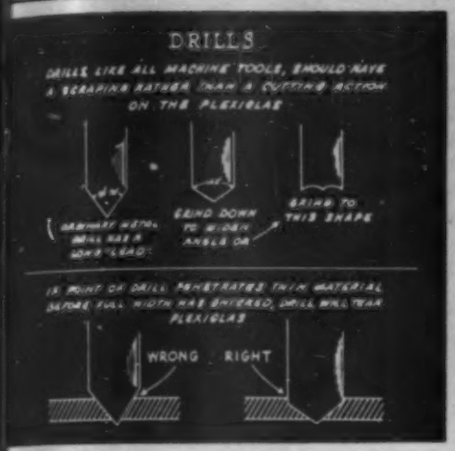
PARKER-KALON

Quality-Controlled

SELF-TAPPING SCREWS

Give the Green Light • to War Assemblies

Drilling Plexiglas


DRILLS
DRILLS LIKE ALL MACHINE TOOLS, SHOULD HAVE A SCRAPING RATHER THAN A CUTTING ACTION ON THE PLEXIGLAS
GRIND DOWN TO HIDDEN ANGLE OR
GRIND TO THIS SHAPE
IF POINT OF DRILL PENETRATES THIN MATERIAL BEFORE FULL WIDTH HAS ENTERED, DRILL WILL TEAR PLEXIGLAS
WRONG
RIGHT

Drills for PLEXIGLAS *should be ground with very little "lead" to reduce danger of tearing the plastic.*

The new 48-page PLEXIGLAS Fabricating Manual explains this fabricating tip and suggests hundreds of equally valuable short-cuts for speeding the production of PLEXIGLAS military, naval, and defense units.

As pioneers in the field of acrylic plastics, Rohm & Haas is glad to pass along this information so that each piece of PLEXIGLAS can play its full part in the defense program. Write for your copy today.

THE CRYSTAL-CLEAR ACRYLIC PLASTICS

PLEXIGLAS
SHEETS AND RODS

CRYSTALITE
MOLDING POWDER

PLEXIGLAS *and* CRYSTALITE *are the trade-marks, Reg. U. S. Pat. Off., for the acrylic resin thermoplastics manufactured by the Rohm & Haas Company.*

THIS picture graphically illustrates the tremendous importance of permanently transparent PLEXIGLAS *in modern aircraft. Through clear* PLEXIGLAS *sections that are able to withstand the most powerful air pressures, the bombardier of this Douglas bomber enjoys maximum vision in every direction.* PLEXIGLAS *is aviation's standard transparent plastic.*

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA, PA.

Manufacturers of Leather and Textile Specialties and Finishes . . Enzymes . . Crystal-Clear Acrylic Plastics . . Synthetic Insecticides . . Fungicides . . and other Industrial Chemicals

"O-I Plastics reflect . . . *the experience and resources of the developers of Duraglas containers . . . The World's Finest*"

OWENS-ILLINOIS PLASTIC EXPERTS ARE GOING FULL SPEED MAKING

U. P.

(Unmentionable Products)

Secret war materials are called "U. P." (unmentionable products) by the British. Today, Owens-Illinois is making many plastic unmentionables that go into war materials.

Our modern equipment, research facilities and experience qualify O-I to make these war plastics.

For obvious reasons we are not illustrating these plastic parts. But the millions of them we are making to help speed victory will culminate into a still broader, wiser experience that will be available to manufacturers when the victory is won.

We are equipped for:

Automatic Rotary Compression Molding
Injection Molding
Upright Compression Molding
Printing on Plastics

Plastics Division... **OWENS-ILLINOIS**

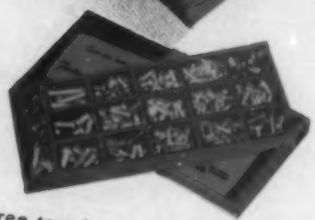
TOLEDO OHIO

Quicker... stronger Plastic Fastenings!

NO TAPS!
NO INSERTS!
Actually cuts its own thread as you drive it!

SHAKEPROOF
TYPE 25 THREAD-CUTTING SCREWS

SNUG AND TIGHT!
Each screw remains in the perfect mating thread it has cut itself!



Free test kit includes variety of head styles and sizes plus complete instruction data!

SAVE VITAL MAN-HOURS!

Speed up the assembly of plastic parts with this screw which eliminates tapping. Specially designed for tough and brittle plastics, it cuts its own thread without causing dangerous stresses or fracturing. Try it on any application — you'll quickly appreciate its many production advantages. Write for free sample test kit today!

SHAKEPROOF inc.

"FASTENING HEADQUARTERS"
2501 North Keeler Avenue • Chicago, Illinois

Distributor of Shakeproof Products Manufactured by ILLINOIS TOOL WORKS... Plants at Chicago and Elgin, Illinois
In Canada: Canada Illinois Tools, Ltd., Toronto, Ontario
SEMS FASTENER UNITS • THREAD-CUTTING SCREWS • LOCK WASHERS • COWL FASTENERS • LOCKING AND PLAIN TERMINALS • LOCKING SCREWS • RADIO AND INSTRUMENT GEARS • SPECIAL STAMPINGS

HOW TO GET THE MOST OUT OF YOUR LATHES

No. 2 in a series of suggestions made by the South Bend Lathe Works in the interest of more efficient war production.

Keep Them Well Oiled

For lack of oil the bearing was lost;
For lack of a bearing the tank was lost;
For lack of a tank the battle was lost;
All for the lack of a film of oil.

Cleverly paraphrasing the ancient rhyme about the horseshoe nail, a young army officer is said to have used the above verse to emphasize the importance of lubrication in mechanized warfare. And this thought is just as applicable to the battle of production in American shops as it is to the tank battles in distant lands.

The proper lubrication of lathes and other machine tools will contribute much to our total war effort by preventing unnecessary interruption of production. It will also save scarce strategic materials and highly skilled technical labor by reducing to a minimum the demand for replacement bearings, parts, and machines.

South Bend Lathes, like other fine machine tools, have large oil reservoirs, felt wicks, and oil retainers to guard against lack of oil due to temporary neglect or oversight. But for best results the lathe should be oiled at regular intervals. Even a camel must have an occasional drink.

All bearings should be oiled at regular intervals

Make Oiling a Habit

All oil holes and oil cups on the lathe should be filled at least once a day — oftener when the lathe operates day and night — or when top speeds and feeds are employed. The best method is to fill each oil hole in a regular sequence so that oiling becomes a habit and no oil holes are overlooked. When the lathe is in service on two or more shifts, oiling the lathe should be the first daily task of each operator.

To help the inexperienced operator find the oil holes, a circle of brightly colored paint may be applied around each oil cup. Different colors of paint can be used to indicate different grades of oil.

Use Correct Grade of Oil

When the correct grade of oil is used in a well designed bearing there is little or no metal to metal contact and practically no wear. However, when the wrong grade of oil is used, or if the oiling is neglected, the oil film will break down and the fine finish of the bearing surface may be damaged in a short time.

The V-ways of the lathe bed, and the dovetails should be oiled as often as is necessary to maintain a good oil film. Touching the bed way with the tip of the finger will indicate whether or not it is coated with a film of oil.

Motors should be lubricated according to the motor manufacturer's instructions which are usually attached to the motor. Care should be taken to avoid getting oil on rubber V-belts or flat leather belts, as it is injurious to both.

Clean Lathe After Oiling

After the oiling has been completed, the excess of oil should be wiped off with a clean cloth. The lathe should be kept clean. Dirt, chips, or rust should not be allowed to collect.

Write for Bulletin No. H2

Bulletin No. H2 giving more complete information on oiling the lathe will be supplied on request. Oiling charts for South Bend Lathes, and reprints of this and other advertisements in this series can also be supplied. State quantity wanted, also serial numbers of lathes for which oiling charts are needed.

SOUTH BEND LATHE WORKS

Dept. 186 • South Bend, Ind., U. S. A. • Lathe Builders for 35 Years

THESE PRODUCTS

Never saw a Rubber tree

PLASTICS are replacing vital rubber as well as saving scarce metals. Here is another accomplishment in Auto-Lite's long record in developing and applying plastics to a wide variety of rubber and metal products. Frequently production is simplified, designs are improved and often costs are lowered substantially. Our experience in both compression and injection moulding is freely available to manufacturers who believe plastics might be the solution to their production problems. You may find plastics not just an *out*—but an advance, for the duration . . . and after.

THE ELECTRIC AUTO-LITE COMPANY
Bay Manufacturing Division
BAY CITY • MICHIGAN

Specify
AUTO-LITE
PLASTICS
FOR THE DURATION . . . AND AFTER

The courage to say "yes" when it's easy to say no

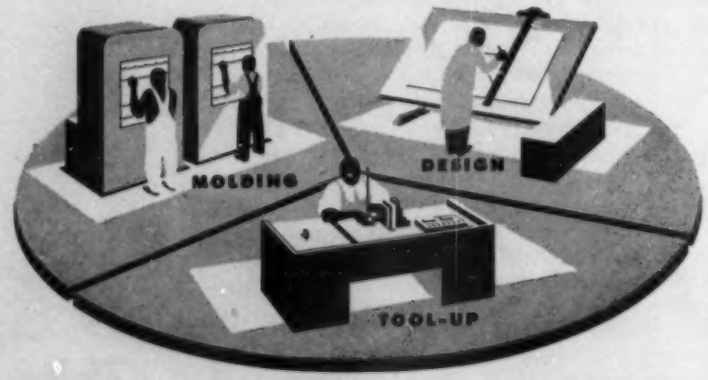
There are plenty of good reasons these days for turning down new business. Loaded production lines. Uncertain supplies. Delivery schedules changing from day to day. Longer hours for everybody . . . Certain types of orders can't be accepted without sacrificing efficiency or throwing vital schedules out of whack.

Yes, there's good reason in some cases for saying "no." But we'd like you to keep this in mind:

We say "yes" in every case it is physically and humanly possible to squeeze your job into our schedules. As you know it takes time, even with an AA-1, to get the necessary tools for a new custom molding. Then there are physical limits to the productive capacity of presses. But the way to hurdle design, tool-up, and production difficulties is to *stay in there pitching* with every ounce of man and machine power you've got. That's what we've been doing, and the efficiency records of our organization prove it.

When you need help, write, wire, or phone. You may be sure we'll do everything in our power to turn your parts out. There's a place for courage on the production lines as well as on the firing lines.

The Plastics Round-Table is the name we've given to the conference method of tackling problems. We put specialists on design, tool-up, and production to work, *together*, on all new jobs. It helps to get all the facts straight—from start to finish. It worked well before the war, and it's doing an even bigger job now.



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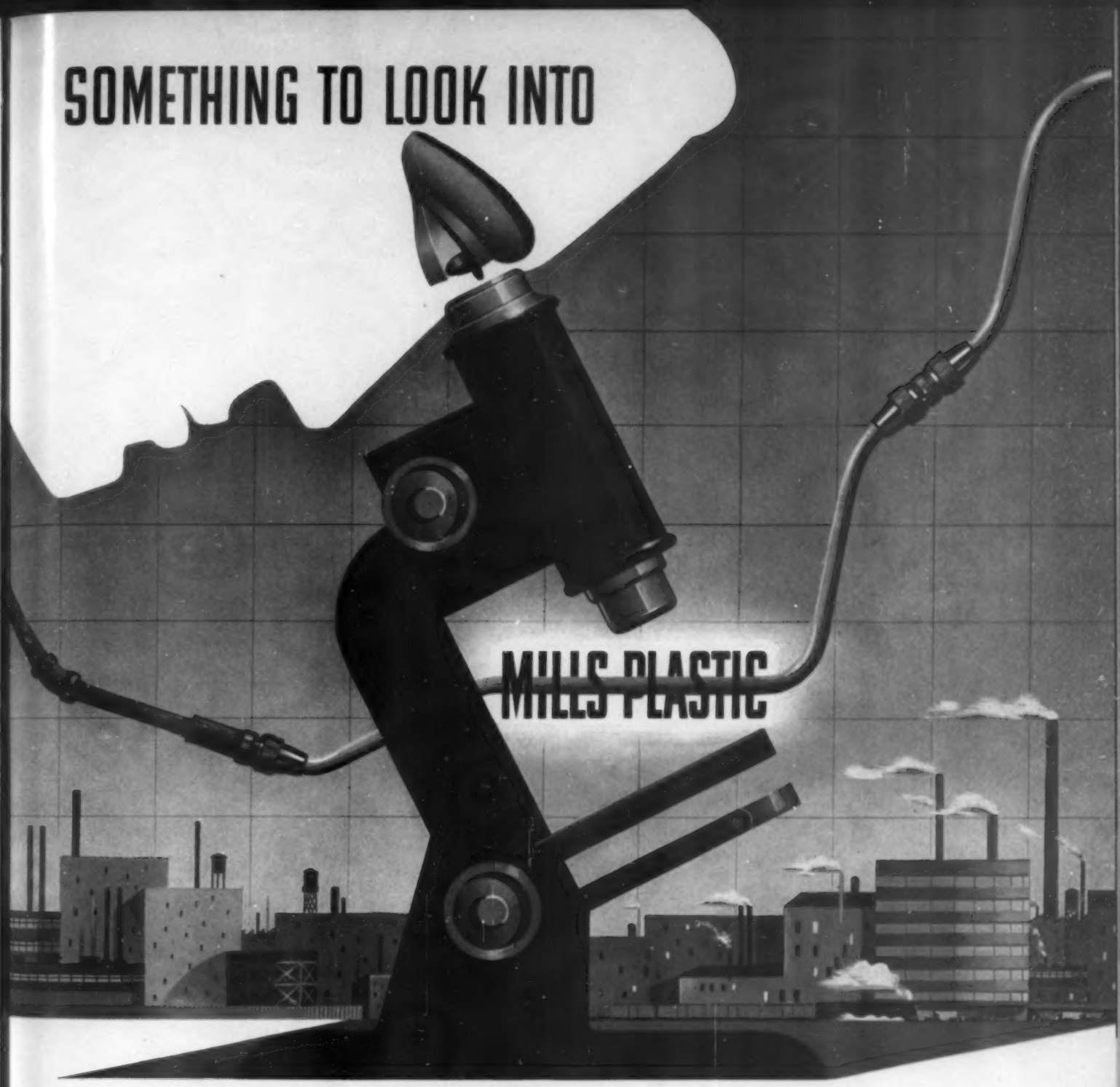
Kurz-Kasch, Inc., 1417 South Broadway, Dayton, Ohio. Branch Sales Offices: New York, Chicago, Detroit, Los Angeles, Dallas, St. Louis, Toronto, Canada. Export Office: 89 Broad Street, New York City.

SOMETHING TO LOOK INTO



● When lack of strategic materials made it necessary for science to produce replacements that could solve difficult industrial and production problems, thermoplastics jumped to the fore . . . . MILLS PLASTIC immediately became something to look into!

The possibilities of MILLS PLASTIC are many, starting first with tubing that was soon found to have surpassed copper tubing in its resistance to most chemicals, ease of handling and installation, and light weight. Then came fittings with molded threads and knurled faces in flare type unions and half-unions. Tee's are now available and elbows will be ready by December 1. Other MILLS PLASTIC products have been designed and soon will be on their way to help speed Victory. Inquire about MILLS PLASTIC as a replacement for critical metals. Consult our engineers without obligation.

Your signature on your letterhead brings you a copy of this catalog containing data and illustrations of molded thermoplastics . . . and MILLS PLASTIC • • • •

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Molders of Tenite, Lumarith, Plastacele, Fibestos, Lucite, Crystallite Polystyrene, Styron, Lustron, Loalin, Vinylite, Mills-Plastic, Saran and other Thermoplastic materials.

812 WEST VAN BUREN STREET ● CHICAGO, ILLINOIS

● BUY UNITED STATES WAR BONDS ●

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Plan ahead for PLASTICS

Long range planning—for the most profitable use of plastics—will help you enter the post-war period with confidence. Now is the time to map your future campaign. You can get strategic assistance—accurate, impartial information—from the Research Laboratory of Plastics Institute. ★ ★ ★ Plastics Institute has complete facilities for specific property tests, to show the possibilities and limitations of plastics materials—for development and design of plastics parts—one-of-a-kind models. The technical staff is thoroughly experienced in the commercial applications of plastics, and is prepared to give you impartial, confidential recommendations on methods and materials. A letter outlining your plans and problems in plastics will bring a prompt, helpful response.

Plastics Institute conducts Study Forums in plastics in many industrial centers, for the convenience of all interested in plastics. Each Forum is conducted by a recognized industry authority. Discussions are based on assignments prepared by the technical staff. Plastics Institute also offers resident courses in Plastics Engineering, at Los Angeles, California, and illustrated Basic Lesson Assignments, by mail.

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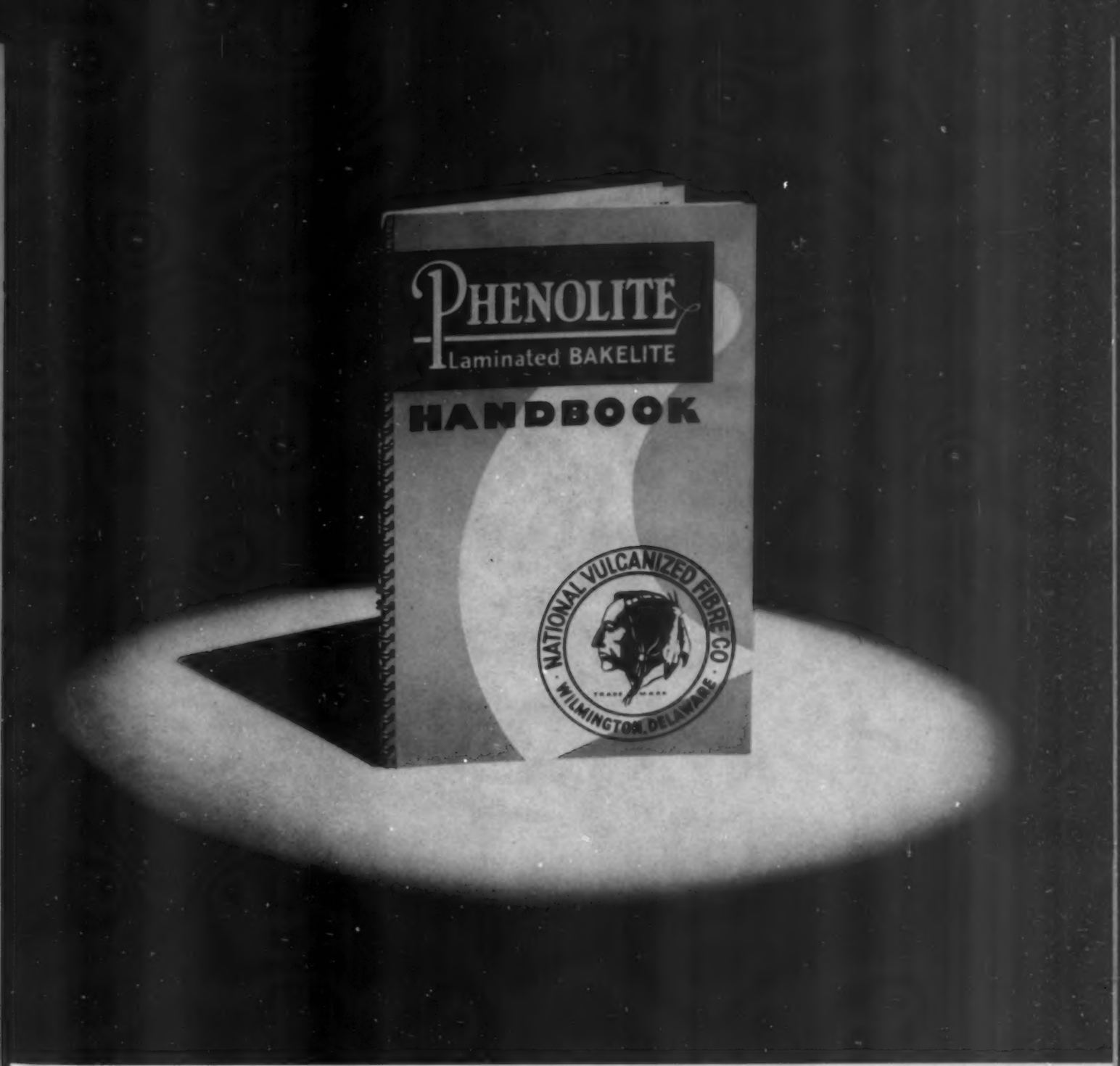

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Knockout!

You Land 'em by Slugging and Thinking

Are you busy making equipment to help the good uncle land his Sunday punch — products used in planes, tanks, ships, cars or communications? Then you realize the ever-increasing importance of molded plastics — are probably aware that on parts demanding the greatest engineering and production exactness, you're most apt to find our mold mark. And you've undoubtedly drawn your inferences . . .

Are you busy thinking of your product after we've counted the Japs and Nazis out? Then you'll be thinking increasingly in terms of molded plastics. We'd like to do your thinking with you. After the war our production facilities will be entirely at your service (as, perhaps, they are today, if your output gets priorities). But in any case, we can think development and design with you now. **And if this phase of your production is attended to before the rush starts — in conjunction with our highly skilled engineers — things will roll more smoothly for you after the Big Job's finished!** Let's talk it over.

•

COMPRESSION

INJECTION

TRANSFER

& EXTRUSION

MOLDING OF ALL

PLASTIC MATERIALS

CHICAGO MOLDED 83 PROD. CORP.

CHICAGO MOLDED PRODUCTS CORPORATION

Precision Plastic Molding

1046 N. KOLMAR AVE., CHICAGO

What can a toy pullman car teach a war plant engineer?

It seems a far cry from a tiny toy railroad car to a big dead-in-earnest bomber. But *is it?*

Thanks to modern plastics, the manufacturer of airplane accessories may learn from methods used to make peacetime articles. A case in point is the better, lighter, deftly-designed miniature Pullman until recently produced by the A. C. Gilbert Company at its factory in New Haven, Connecticut. This plant is now converted to all-out wartime production.

Here clever use is made of Watson-Stillman Plastic Molding Presses. A difficult casting was accomplished by the use of *both vertical* and *horizontal* rams for the coring of the windows, doors and chassis openings. The die construction was simplified so that the die could be interchangeable to run either the Pullman car or a Baggage car.

WATSON-STILLMAN PRESSES SERVE A. C. GILBERT CO. The Watson-Stillman Press shown above is suitable for the most complex and intricate molding assignments. A new die can fit it to new uses.

Watson-Stillman engineers are always available to work with you. Let them advise you on ways to meet war production requirements with presses which can quickly be changed over to meet future manufacturing needs which may be different in character. The Watson-Stillman Co., Roselle, N. J.

Here's something worth fighting for

The right of a father to get down on his knees and play with his son . . . secure in the knowledge that an undictated future of peace and opportunity awaits them both—that's the kind of freedom we're fighting for today. Isn't it worth every ounce of energy we can put forth?

27s2

WATSON-STILLMAN

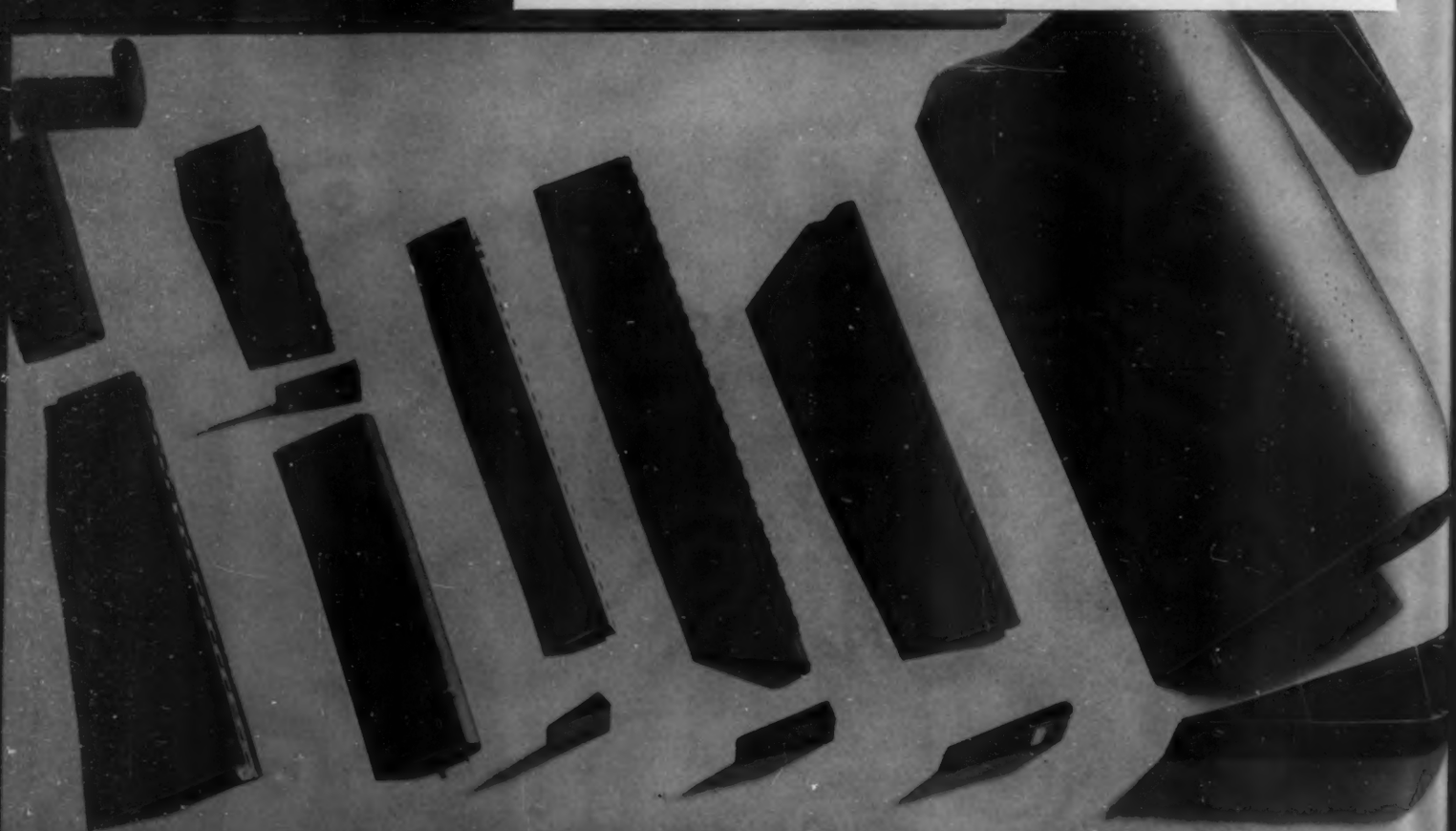
Engineers and Manufacturers of Hydraulic Machinery and Equipment—Hydraulic Presses, Pumps and Jacks, Forged Steel Valves and Fittings

TAYLOR PIONEERED IN LAMINATED PLASTICS CONSTRUCTION OF VITAL AIRCRAFT PARTS

Taylor Laminated Plastics Construction of Trim Tabs is now standard on such aircraft as the famous Bell Airacobra P-39 Interceptor Pursuit, the Martin B-26-B Bomber and others. It is approved by the United States Army and Navy. Tests are being conducted on this type of construction for trim tabs, servo-tabs, wing flaps and radio antennae masts in many aircraft laboratories.

Pre-fabrication by Laminated Plastics Construction of more and more aircraft parts offers an important means of speeding aircraft assembly. Working with extreme precision from the manufacturer's specifications, Taylor provides the straight-line mass production of a specialist in their field, with unlimited facilities including the manufacture of their own materials.

TAYLOR FIBRE COMPANY
NORRISTOWN, PA.
Pacific Coast Headquarters: 544 South San Pedro Street, Los Angeles, Cal.



TAYLOR

LAMINATED PLASTICS • Vulcanized Fibre • Phenol Fibre • SHEETS, RODS, TUBES FABRICATED PARTS

* *Boulder Dam in Colorado is one of the most impressive of all American Dams. A gigantic engineering feat, its construction was accomplished in spite of its many obstacles. It took 3,250,000 cubic yards of concrete piled up to withstand the pressure of water increasing from surface to base. Here indeed is a tough job that has earned the praise and plaudits of all connected with its construction.*

TOUGH JOBS DON'T FAZE US.. EITHER

Our job is not building dams. Ours is the job of creating, designing and fabricating plastics. By analogy, we sometimes run up against a problem that's just as tough as the building of Boulder Dam and, likewise, we too come out on top. We don't receive the same universal praise and acclaim, but we have built up an enviable reputation for doing the "impossible" jobs. We'd like to prove it on your next plastics job. Call us in.

We may be able also, to design plastic materials to take the place of hard-to-get metals. Ask us about it.

"ETHYL RUBBER"

Produced in

Tubes, Rods and Sheets

INJECTION MOLDED PARTS
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Seamless extruded tubing and shapes of Vinylite, Ethyl Cellulose or Cellulose Acetate Plastics, etc.

Sheets, Tubes and Rods of Nitro Cellulose, Cellulose Acetate or Ethyl Cellulose Plastics.

Fullest cooperation will be given to manufacturers with high priority ratings requiring the above materials.

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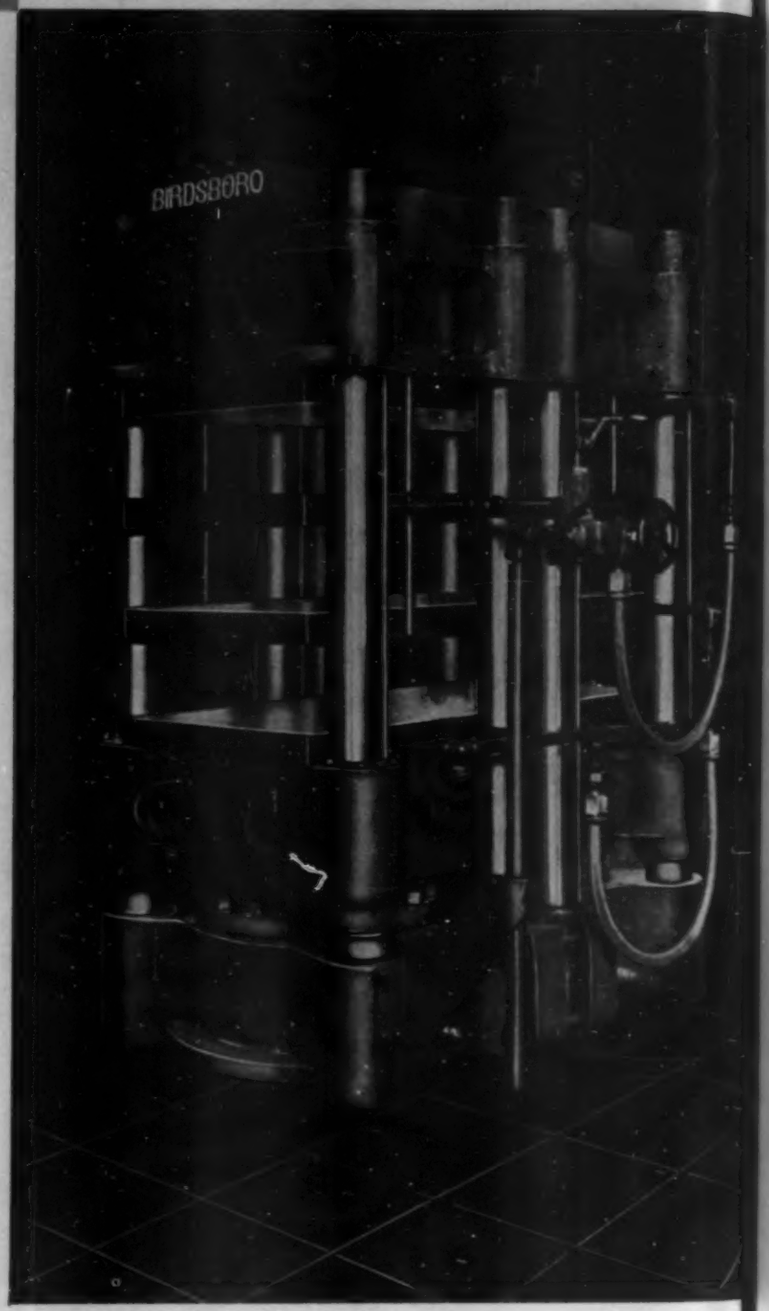
by Performance



Tnis Twin Cylinder Birdsboro Hydraulic Press is typical of many that are helping to speed the production of plastic parts for airplanes.

Whatever your press problem—multiple platen sheet, specialized, or general molding — it will pay you to consult Birdsboro.

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Hydraulic Presses **Special Machinery**
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Plants at Birdsboro and Reading, Pa.

BIRDSBORO

HYDRAULIC PRESSES

A BOOSTER FOR BOMBS and for *Makalot*, TOO

War Order Of The Day

The booster is a container for a supplementary bomb or shell detonator charge and is one of the first applications of plastics intended 100% for war use.

There existed no parallel civilian job on which to take bearings and yet MAKALOT worked at once. The Superintendent of the Plastic Department of one of the largest molders of Bomb Boosters writes:

"The (Makalot) 1155 is the only material that could do this job as we are doing it; since we are molding the boosters about 10% faster than anticipated. We have perfect wall thickness, uniform shrinkage and a beautiful molding in general."

FOR OTHER WAR ORDERS

Makalot has the right material and rigid control so essential for your war-time requirements in dependable molding materials.

To Home Front Molders

Makalot offers a superlative line of closure materials. Deep draft, or short draw—stripping or rigid set—we have materials designed especially to meet your closure molding requirements.

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The Independent Producer of Superior Plastics

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CORPORATION

262 WASHINGTON STREET • BOSTON, MASSACHUSETTS

MOLDING COMPOUNDS • FABRIC AND PAPER IMPREGNATING RESINS • TUBES, RODS AND SHEETS • PHENOLIC LACQUERS • VARNISHES • ADHESIVES

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our brand new

PLASTICS WEATHER-OMETER TEST

tells the story . . . !

Plastics for planes . . . Plastics for cars . . . Plastics for tanks . . . Plastics for warships . . . the story of chemistry's newest miracle is in its infancy! The future of the Plastics Industry depends upon the performance record of the new Plastics products in actual usage. Can they stand weathering and exposure? Can they resist the action of sunlight? Time will tell . . . but progress can't wait for that!

Announcing a New Plastics Weather-Ometer Test. We have perfected an accelerated weathering test that concentrates within the short space of 24 hours, the effects of protracted outdoor exposure upon your Plastics. Your product is inserted in the Weather-Ometer, a standard instrument that produces, in an accelerated way, the alternating effects of exposure to sunlight, rain, heat, and cold.

Thus this test tells you *in advance,* the weathering capacity of your Plastics over any specified length of time . . . under any climatic conditions. If your Plastics are used out-of-doors . . . write for complete details of this test immediately!

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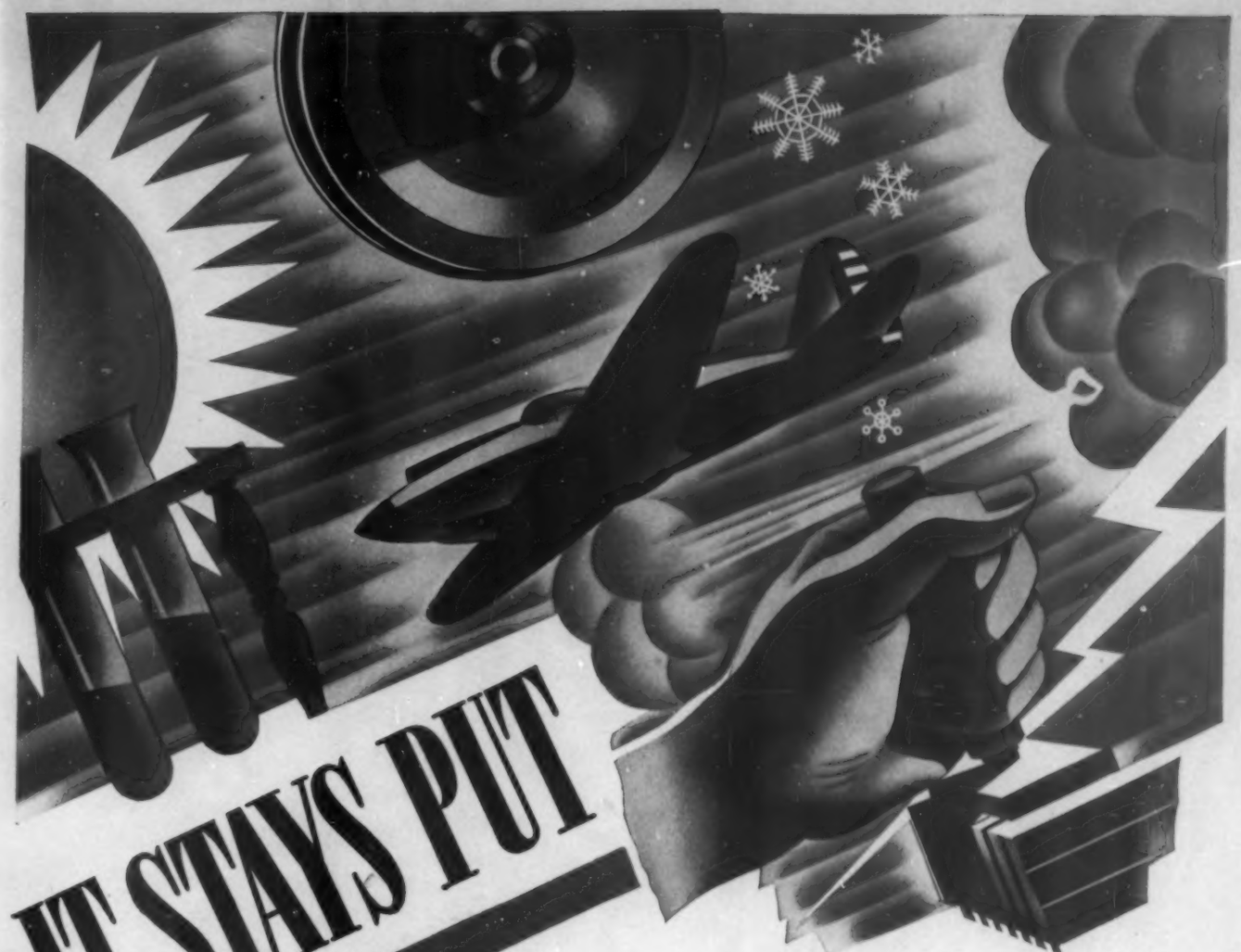

IT STAYS PUT

One thing above all others makes Formica the valuable material it is in so many industries — electrical, mechanical, aviation, chemical, and that is: once a Formica part is installed it remains unchanged almost regardless of conditions. It really stays put!

When you build a part of Formica you can challenge the elements to do their worst and they won't accomplish much.

Changes in temperature do not alter its dimensions appreciably. Humidity or lack of it leaves it untouched. Electrical currents can't push through it because it is an excellent insulator for high or low frequency currents. No atmospheric condition, anywhere in the world, can cause it to corrode, or roughen and destroy its surface, because it is inert chemically . . . The Formica data book tells this story in terms of precise engineering tests. Send for it.

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"INTERLOX"†

Extruded Plastics, Inc. manufactures seamless plastic tubing in a wide range of diameters, wall thicknesses and colors from different base synthetic resins for various purposes. Advanced engineering methods and exclusive processing formulae are building for EXTRUDED PLASTICS INC. a reputation for unmatched quality and uniformity. The more important types of plastic tubing include:

GRADE TT, made from cellulose acetate butyrate—(Tenite II). Clear, transparent, sizes from 3/16" to 1½" outside diameter. Satisfactory working range 32° F. to 150° F. For gas, liquids, beer, milk, oil, etc. Colors on special order.

GRADE S, made from vinylidene chloride (Saran*). Flexible tubing, sizes from ⅛" to ¾" outside diameter. Satisfactory working range 32° F. to 160° F. Unaffected by practically all acids, alkalis and organic solvents. *(*Trade Mark, The Dow Chemical Company.)*

GRADE V-1, made from vinyl butyral. Translucent lemon shade only, sizes from ⅛" to 1" outside diameter. Extreme flexibility makes Grade V-1 highly desirable as replacement for rubber tubing in many installations. Satisfactory working range —40° to +140° F.

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GRADE HR, Hollow Rod Stock, made from cellulose acetate butyrate. Round and hexagonal. Minimum inside diameter 3/16". Maximum outside diameter 1⅛". Stock sizes now available for immediate delivery.

ALL TUBING can be furnished in long length coils up to ⅝" outside diameter. Larger sizes in 12' lengths. Technical data sheets and details of standard diameters and wall thicknesses, upon application.

"INTERLOX"† Functional Shapes are widely used for trimming of wall board, insulating board, etc. Special shapes—maximum width 3"—for industrial use to customer's specification. †Trade Mark Reg. U. S. Pat. Off.

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SPECIAL PHENOLIC RESINS

for... **PLYWOOD ADHESIVES**

LAMINATING VARNISH

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Also **CAST PHENOLIC RESINS**

in sheets, rods, tubes and special castings to specifications. Available in all colors in translucent, opaque, clear and mottled tones. • Our engineers and chemists will be glad to cooperate with you in demonstrating the practicability of either liquid or cast phenolic resins as applied to your product.

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SPEED SELECTOR DIALS, HANDWHEELS and COLLET CHUCK GUARDS

NEW Plastics Development by Eclipse

Saves Man-Hours and Production Time for Machine Tool Builders . . .

Another FIRST by Eclipse, these new Plastic developments in HEAVY MACHINE TOOL PARTS are saving valuable Wartime machining, finishing and assembly costs — reducing man-hours-per-machine to help Machine Tool Builders meet Government demands for MORE PRODUCTION SPEED.

It takes engineering imagination to design these parts in PLASTICS, and Eclipse does it again — improving Machine Tool efficiency, convenience, and appearance.

The EXTRA advantage of Improved READABILITY is demonstrated in the Gisholt Machine Co. Plastic Speed Selector Dials, above, made by Eclipse Moulded Products Co. Improved READABILITY is achieved easily by *color contrast*, moulding the inner Dial of RED Plastic with White markings, and the outer Dial of BLACK Plastic with White markings. Distinctly superior to the all-metal dials, these contrasting plastic dials and markings enable even inexperienced hands to produce accurate work — faster.

High-impact Plastic is used and no machining is required before assembly.

Eclipse Plastic Handwheels, used on Gisholt Saddle-Type Lathes have a specific gravity ⅓ lighter than aluminum, and show definite advantages over former metal parts . . . advantages that may be adapted to a wide variety of modern Machine Tools. Dies for these precision built handwheels were made on a Gorton Super-Speed Mill.

Machine Designers and Engineers!

Eclipse Engineers will be glad to assist in your conversion and engineering problems.

For Suggestions and Quotations on your parts send sample or blueprint.

Eclipse MOULDED PRODUCTS CO.

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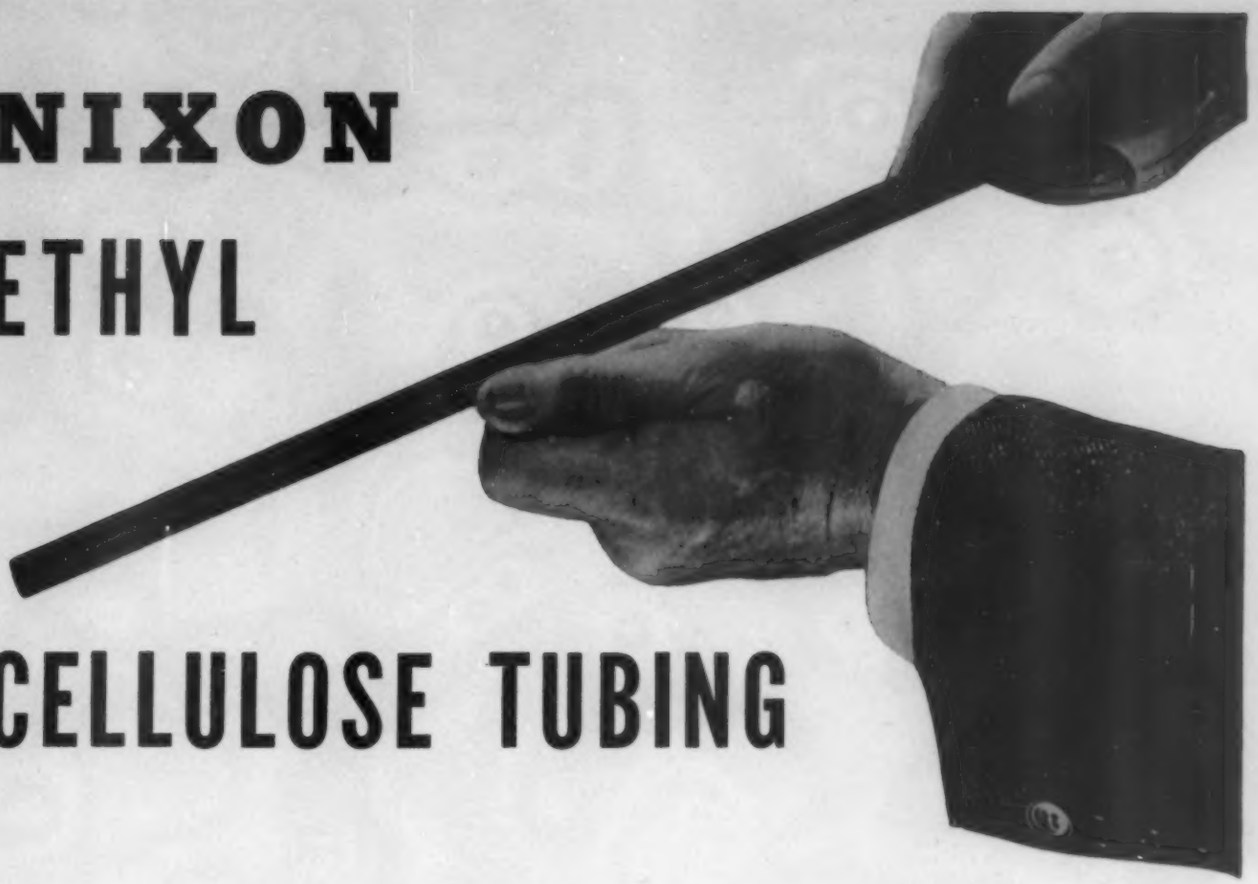
COMPRESSION . . . INJECTION . . . EXTRUSION
RESINOX • TENITE • PLASKON • DUREZ • LUCITE • BEETLE
BAKELITE • LUMARITH • POLYSTYRENE . . . and all other materials

NIXON ETHYL CELLULOSE TUBING



THE solution to the metal tubing shortage, in many important applications, can be found in the use of Nixon Ethyl Cellulose materials.

Extruded in continuous lengths, this tubing is tough. The illustration has walls approximately 1/8" thick. The interior diameter is 5/16". Such tubing can be extruded in any reasonable size. Although made of a thermoplastic material, it has many features not usual in thermoplastics, an outstanding characteristic being that the material retains its shape and flexibility at extremely low temperatures.

Nixon Ethyl Cellulose is highly water resistant as well as resistant to alkalis and most chemical compounds. It has high dielectric strength. Joints can be made absolutely tight through the use of adhesives. The weight of this tubing is exceedingly light in relation to the strength of the material. Aging does not deteriorate its fine qualities.

NIXON *Plastics*

NIXON NITRATION WORKS, INC., NIXON, NEW JERSEY

Mfrs: NIXON ACETATE MOLDING POWDERS • NIXONITE (acetate) and NIXONOID (nitrate), sheets, rods, tubes

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Why should these pictures remind you of Kys-ite?

Learn to say "KYS-ITE". It's the name of the new miracle plastic that everyone's talking about. If you want a picture of its possibilities just read the story below. It will take you only one minute and ten seconds.

Strong. Molded from strong pulp fibre and synthetic resin, KYS-ITE can be preformed to shape before curing. It has four to five times the impact strength of ordinary plastics.

Lightweight. America's new lightweight champion, KYS-ITE weighs only about half as much as aluminum. However, for all its lightness, it is resilient and sturdy.

Tough. It's practically non-shatterable and almost impossible to chip in ordinary use. Jumbo-tough KYS-ITE has been used to replace many metal machine parts.

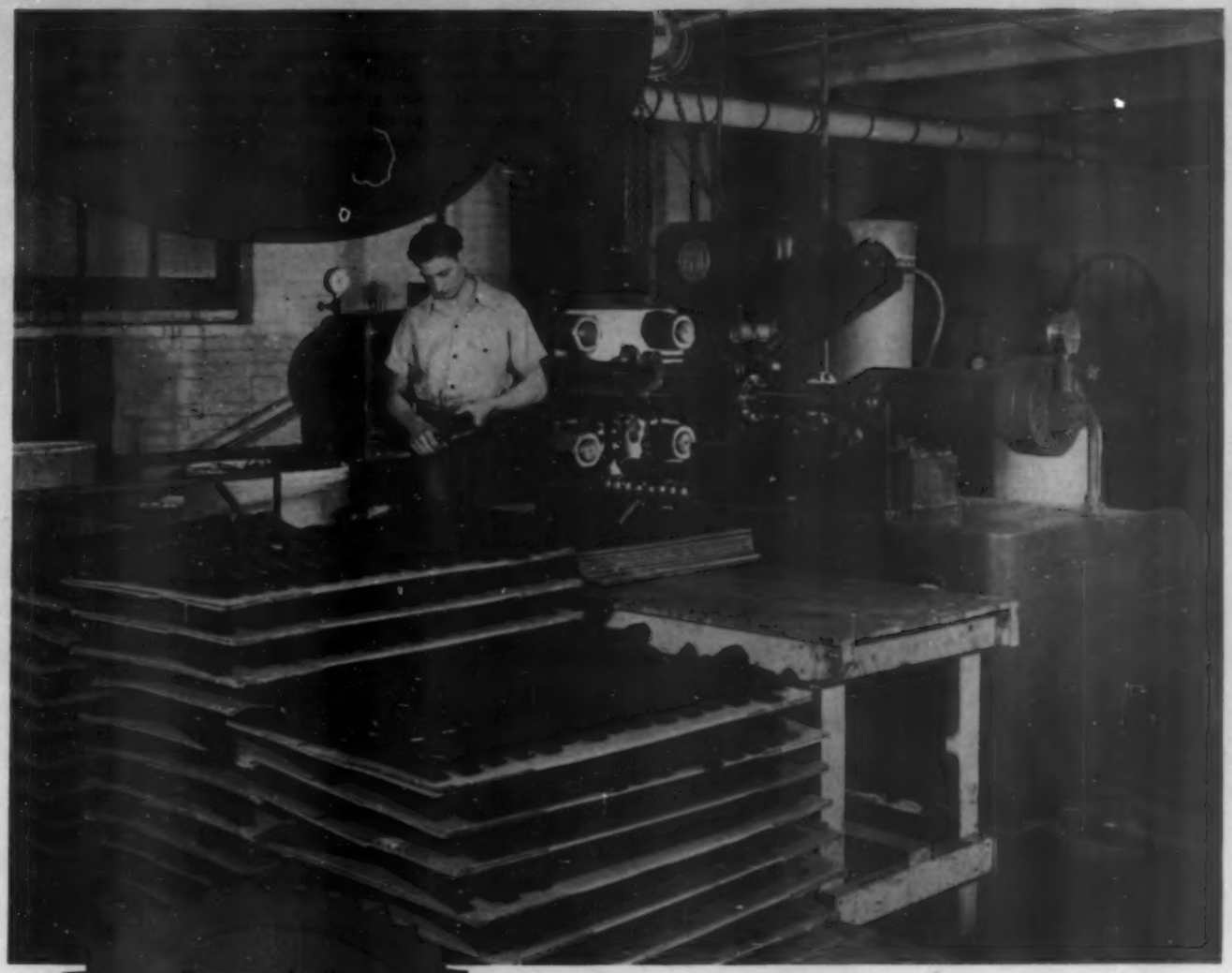
Quiet. Because KYS-ITE is non-resonant and non-reverberating, it's ideal for trays, small parts, machine cases, and scores of other uses where it's desirable to eliminate noise.

Durable. Time deals lightly with KYS-ITE'S lustre. Even boiling it for days in soap, salts, and acids fails to disfigure or warp it. Alcohol, grease, and mild alkalies can't stain it.

Beautiful. A real beauty winner, KYS-ITE is available in a wide range of rich, sparkling colors. Best of all, its loveliness can be retained simply by wiping with a damp cloth.

• LET KYS-ITE MOLD YOUR FUTURE •

KEYES FIBRE COMPANY, WATERVILLE, MAINE



Like every other industry, the plastics industry has its bearing problems—although at present somewhat limited in extent and variety.

Wherever wheels and shafts turn in plastics production however, they turn smoother, faster, more accurately and more economically when they turn on Timken Tapered Roller Bearings.

Plastics rolling mills offer one of the most important opportunities for Timken Bearing applications just now; opportunities for power saving, increased output, greater rolling precision and lower maintenance cost.

It will pay you to check up on all the bearing points in your equipment with the object of giving them Timken Bearing protection and economies.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN

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TAPERED ROLLER BEARINGS

Manufacturers of Timken Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; Timken Alloy Steels and Carbon and Alloy Seamless Tubing; and Timken Rock Bits.

TO ASSURE VICTORY
BUY UNITED STATES WAR SAVINGS BONDS & STAMPS

WHAT HAS SHE GOT TO DO

WITH MOLDING PLASTICS?

(we don't know but we're checking)

We have at least one thing to be thankful for—we are not in charge of advertising cigarettes.

The molding business may be a strain on the nerves today but we have never envied the fellow who had to go into a roomful of Powers models, choose one and then supervise the taking of one of those eye appealing pictures that appear on the back cover of current magazines.

We can take just so much and then we crumble. Free hand sketches are far easier on the nerves.

So, if you are wondering what this is all about, here comes the snapper—

We are molders of all synthetic plastics, past, present, and future. We are so jammed with work that we couldn't solicit your business even if we had material to take care of anything less than A-10.

So what—Have you a place you make notes for the future—if so, please drop our name in it. It will help you, and it certainly will make life easier for us—some time.

"A Ready Reference for Plastics" written for the layman, is now in a new edition. If you are a user, or a potential user of molded plastics, write us on your letterhead for a copy of this plain non-technical explanation of their uses and characteristics. Free to business firms and government services.

BMCO

BOONTON MOLDING COMPANY

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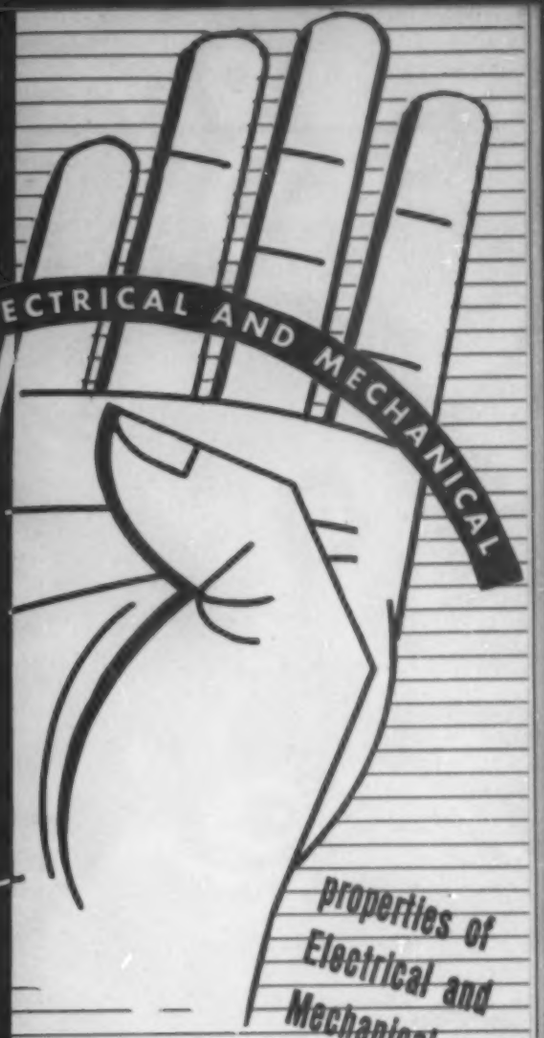
THERE ARE 4 *Catalin* CAST RESINS



It's been a long time since Catalin Cast Resins first won their reputation for color, beauty and unsurpassed machinability. Since then, variations on the basic Catalin formula have resulted in two new materials—one for use where chemical resistance is a prime consideration; the other, a mechanically strong material with excellent electrical properties.

It is this "Electrical & Mechanical" Catalin which is attracting so much favorable attention in today's war-production market. A glance at the properties table to the right will help to explain the marked preference it is being accorded by engineers and manufacturers whose priorities rate only the "finest". One of Catalin's four Cast Resins will be best for your purpose, too!

A detailed story of Catalin Cast Resins—their properties and specifications, how they eliminate expensive molds, their unusual machining qualities, together with suggestions on their fabrication—is contained in this concise, illustrated brochure, just off the press. Write today for your complimentary copy.

Properties of Electrical and Mechanical grade

Specific Gravity	1.305-1.315
Machining Qualities	Excellent
Water Absorption (24 hrs.) %	0.4-0.6
Inflammability	Non-Inflammable
Effect of Ageing Outdoors	Hardens & Yellows
Effect of Ageing Indoors	Hardens & Yellows
Effect of Sunlight	Yellows
Tendency to Cold Flow	None
Tensile Strength, P.S.I.	8,500-10,000
Modulus of Elasticity in Tension, P.S.I.	3.75×10^5
Compressive Strength, P.S.I.	20,000-25,000
Flexural Strength, P.S.I.	10,000-12,000
Maximum Deflection under Flexure, in.	0.14
Impact Strength, Izod ft. lbs. per inch of milled notch	0.48-0.60
Impact Strength, Charpy Notched Ft. Lbs. per In. of notch	0.40-0.60
Impact Strength, Unnotched Charpy Ft. Lbs. per In. of Width	4+
Impact Strength, repeated blows—unnotched—2nd blow	1-4
Shear Strength, 1" Diameter Plunger	5,000-7,000
Hardness, Rockwell	M65-M80
Volume Resistivity, Megohm—Ins.	$1-7 \times 10^6$
Dielectric Strength, Short Time V/M	350-430
Dielectric Strength, Step-by-Step V/M	260-335
Dielectric Constant, 60 Cycles	6.5-7.5
Dielectric Constant, 1,000 Cycles	5.5-6.0
Dielectric Constant, 1,000,000 Cycles	7.4
Power Factor, 60 Cycles	0.10-0.15
Power Factor, 1,000 Cycles	0.01-0.05
Power Factor, 1,000,000 Cycles	0.02-0.05
Loss Factor, 60 Cycles	0.05-0.9
Loss Factor, 1,000 Cycles	0.17-0.25
Loss Factor, 1,000,000 Cycles	0.15-0.35
Arc Resistance, Secs.	200-250
Surface Resistivity, Megohms	6.5×10^6
Thermal Conductivity—10^{-4} Cal. per sec. per sq. cm./1°C. per cm.	3-5
Thermal Expansion, Linear coefficient of per °C.	$8.1-10.9 \times 10^{-5}$
Heat Distortion Point	113-176°F.
Effect of Hot Flames	Chars

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FALL MEETING

SOCIETY of the PLASTICS INDUSTRY

RYE, New York
OCTOBER
12-13

SPI has been cooperating with the armed services in their constantly increasing application of plastics. Where specifications have been involved SPI Technical Committees have assisted in their preparation. As the United States has moved deeper into the war both application and technical plastics problems have correspondingly increased. Now perhaps more than ever before it is important for the industry to collectively summon its production and technical might to assist the Army and the Navy in their plans to successfully prosecute the war.

Many important projects are under way which require cooperative review and future planning. Both the Army and the Navy have undertaken plastics programs which are of vital concern to every company in the industry. Each branch will have an important place on the agenda. In fact the meeting will be primarily devoted to the use of plastics for war purposes.

Speakers from W.P.B. and O.P.A. will be scheduled to discuss problems arising from existing regulations and those pending.

Reservations for the meeting and for hotel accommodations at the Westchester Country Club may be made through the office of the Society of the Plastics Industry.

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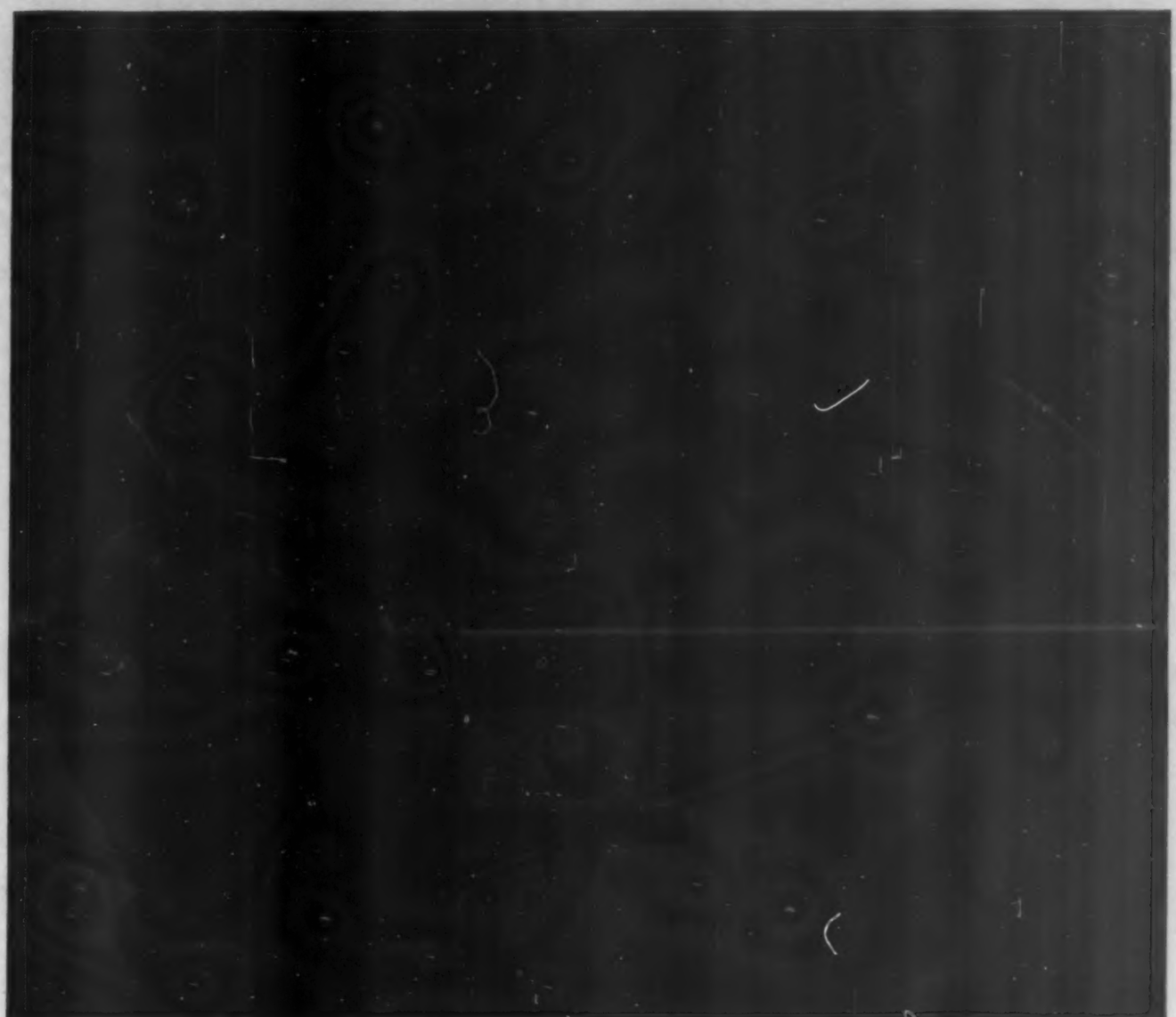

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America's Winged Commandos are on their way . . . training in undisclosed numbers to fly in fleets of swift gliders . . . spearheads of lightning invasions. And many of these new knights of the air will first sight enemy territory through their glider windows of transparent Aero-Quality Lumarith.

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Aero-Quality Lumarith is impervious to water and has excellent weathering qualities. It resists crazing. It speeds production because it is easy to form — simple curves can be formed without heat.

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1943 PLASTICS CATALOG

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. . . . SEND A WIRE TO THE EMERGENCY PRODUCTION SERVICE DEPT. OF KEARNEY & TRECKER

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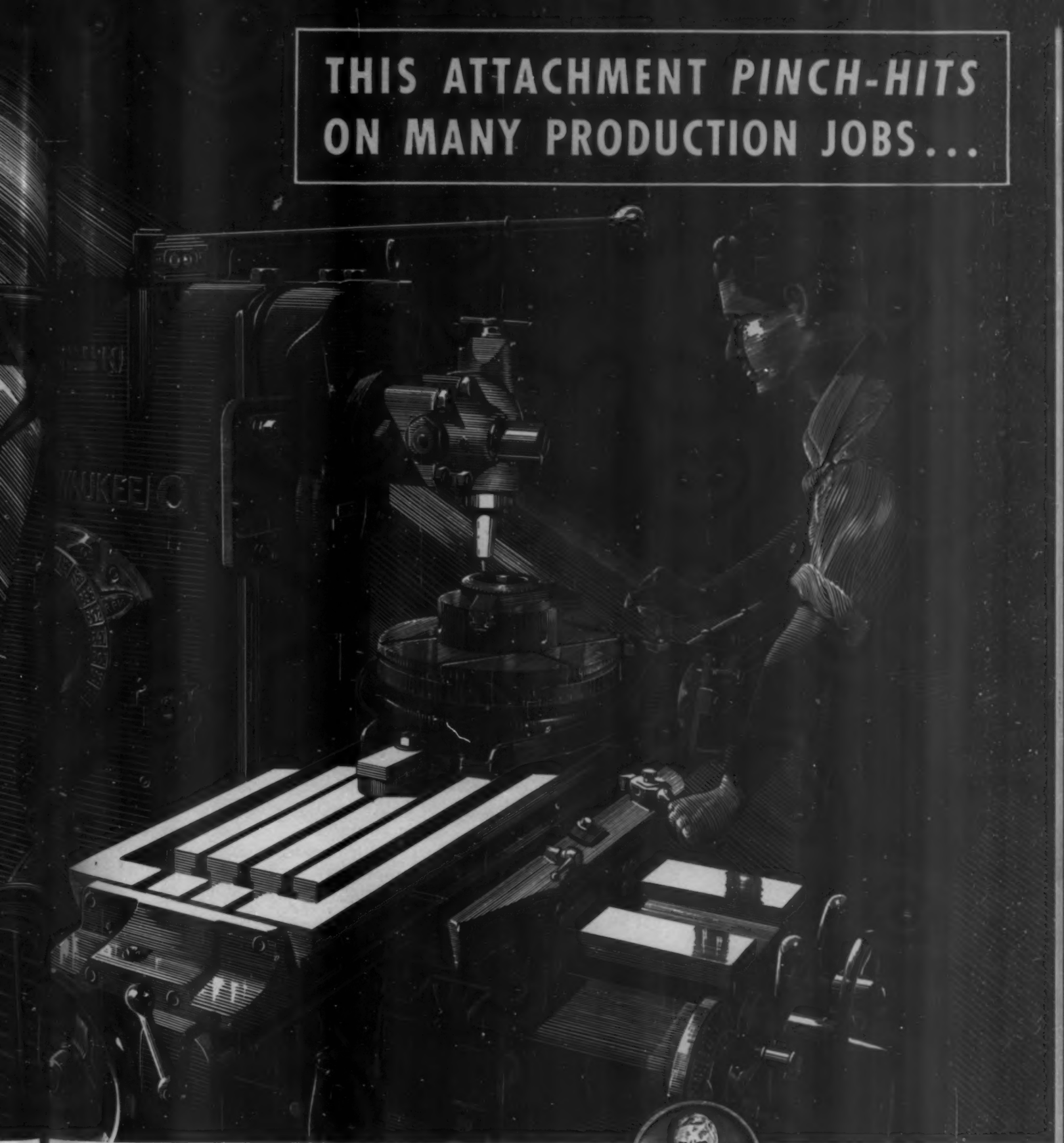

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MODERN PLASTICS
OCTOBER 1942 VOLUME 20 NUMBER 2

OFFICIAL U. S. NAVY PHOTOGRAPH

Insulation aboard U. S. Navy vessels*

by JESSE B. LUNSFORD†

FOR thirty-five years the Navy has been experimenting in plastics for electrical insulation. It has been long, tough, backbreaking work but, withal, rewarding. With so many materials becoming critical today because of the war effort, "plastics" seem to have a magical connotation. Newspapers, magazines and even speechmakers are doing their bit to popularize this subject. The difficulty about this fervent approach to a technical subject is that it is likely to make the technical problems appear too simple. The only proper approach to the problem of plastics application is first to define the job to be done and then to find the material that will do it.

Obviously, to cover the naval background in plastics over a period of twenty-five to thirty-five years involves so many reminiscences and recollections that it would be impossible to do it all in one article. So I am going to discuss the one item which affects all electrical machinery, equipment and appliances whatever their purpose—electrical insulation.

Electrical insulation is, admittedly, the weakest link of the whole chain in the design and performance of electrical equipment. Only in so far as that weak link can be strengthened can further steps in the progress of electrical design be taken. The reinforcing of this weak link has often seemed a difficult and hopeless task. Whatever we have gained in one direction, we seem to have lost in some other.

Again and again in the history of electrical developments, new design ideas have brought fresh hopes and further spurts in electrical design progress. After each such spurt, however, came discouragement, and then another slackening off or rest until new hopes welled up again. In short, the development of efficient electrical insulation, like most engineering progress, has been a series of painful jerks and spasmodic movements past bottlenecks rather than a smooth, continuous and uninterrupted procession. The term "bottleneck," which seems just now to be on every tongue, has come to be associated with the present war effort. Actually, however, it is nothing new. Bottlenecks are present in this war as they were in the last war, and as they are even when there is no war.

(*Please turn to next page*)

* The views expressed herein are those of the author only, and do not necessarily represent the views of the Navy Department.

† Principal engineer (electrical), Research Branch, Design Division, Standards and Tests Section, Bureau of Ships, U. S. Navy.

JESSE B. LUNSFORD

Design progress at all times is simply a series of jumps from one bottleneck to another. This angle is seldom stressed, but engineers and scientists are well aware of it.

Seven ages of plastics

The development of plastics electrical insulation in the Navy extends from 1907 to 1942 and into what might be called the Seven Ages of Plastics—the periods are from 1907 to 1914, inclusive; 1914 to 1918, inclusive; 1918 to 1922, inclusive; 1922 to 1928, inclusive; 1928 to 1932, inclusive; 1932 to 1942, inclusive; 1942, today and tomorrow.

Period 1907 to 1914

The records are not clear as to what insulating materials were in general use in the U. S. Navy prior to 1907. Few old drawings in sufficient detail to disclose such features are now in existence, and such as do exist are very sketchy on this point. Probably the best information on this subject now available is given in the two naval textbooks, "Electrical Installations in the U. S. Navy," Wallen-Martin (1907) and "Naval Electricians' Text Book," Bullard (1908).

The following insulating materials were in general use in the Navy about 1907–08:

Bakelite, in various forms
Mica and micanite, as sheets, washers, etc.
Hard rubber rings, bases, collars, bushings, plugs, etc.
Slate bases and panels
Lignum vitae (boiled in paraffin)
Asbestos board bases and panels (asbestos fibers in Portland cement)
Vulcabeston (asbestos fibers in hard rubber).

Today one would be rather disturbed at the prospect of having to use, aboard ship, insulating material in some of the classes listed above; but the lower voltages then in use and the very much smaller (as compared with the present) electric power distribution systems then installed on shipboard made it easier to get along with such material. From such notes as are to be found in the records of that period, however, it is evident that even then the Navy had ample trouble with electrical insulation.

Period of 1914 to 1918

About 1917 a new term, "approved insulating material," came into use. Obviously such a term indicated the growing necessity of giving more careful consideration to all insulating materials going into electrical equipment for shipboard use and of actually determining their suitability for the purposes intended.

After "approved insulating materials" came into the naval vocabulary, such specific material terms as "porcelain," "hard rubber," etc., began to disappear from the specifications and drawings of electrical equipment for shipboard use. The idea of testing insulating materials and trying to judge them on their merits was making slow but definite progress. Also during this period there was developed a basis for an acceptable list of insulating materials. That acceptable list is still in extensive use today on many classes of insulating materials, but the necessity for it seems to have been born of the war years of 1914–18.

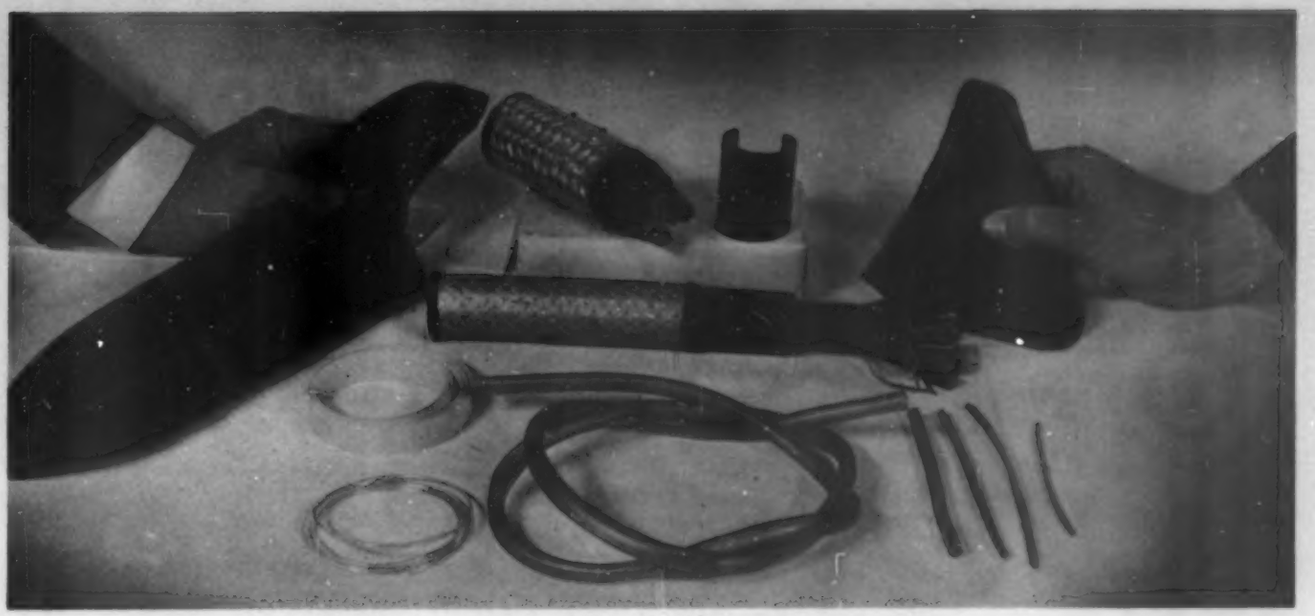
In this early period there were two general classes of plastics in use in the Navy. One class was represented by those numerous compositions employing fillers or fibrous materials in a matrix of thermoplastic material such as shellac, asphalt, etc. This type of plastics never found a very wide application in the Navy, principally because of its tendency to deform at high temperatures and shatter at low temperatures. The other class of plastics, which began to take hold in a big way in the Navy, represented the thermosetting type of material.

The specifications during this period were represented by Navy Department Specification 17-M-6a and Bureau of Engineering Advance Sheets Nos. 79 and 80. These specifications were, however, just in their infancy. Judged by today's standards, one can hardly tell just what the Navy had in mind. However, the data or opinions, scant and imperfect as they were, must have carried some conviction, for this period—and particularly the year 1918—was an important turning point in electrical insulation so far as the Navy was concerned. War is a great proving ground.

The first insulating materials of the molded phenolic type to be used were evidently what are now termed as "cold molded." This early cold molded product was apparently so much cheaper than the hot molded that the two could not compete on the basis of price. On the other hand, the cheaper cold molded product was evidently so poor that it could not possibly have any wide application where moisture conditions were severe. But at that it was better than the insulation which the Navy had used previously and consequently it held partial sway.

Period 1918 to 1922

Apparently the service reports on the cold molded product became so increasingly unfavorable that the next few years (1918–22) were spent in replacing vast quantities of the material acquired during the war with hot molded phenolic material. Before replacing cold molded phenolics completely, an attempt was made to overcome the moisture absorption which ruined their insulating properties. A series of experimental tests was initiated by the Navy, utilizing various impregnating mediums designed to close up the holes or pores in the cold molded product. It was found that paraffin was the best material for sealing against water, but the greasy surface it left caused the collection of so much dust, grime, etc., as to result eventually in dielectric failures in the molded insulating parts. Thus the sealing of the inner pores of the material caused us to lose the effectiveness of the outer surfaces. Furthermore, it rendered these molded parts highly flammable. And so was born the question of how to determine flame resistance, which in turn led to important discoveries in plastics insulation.



Every ship in the U. S. Navy is a floating electric power plant. Here are component parts of a piece of ship cable as approved by the Navy

Period 1922 to 1928

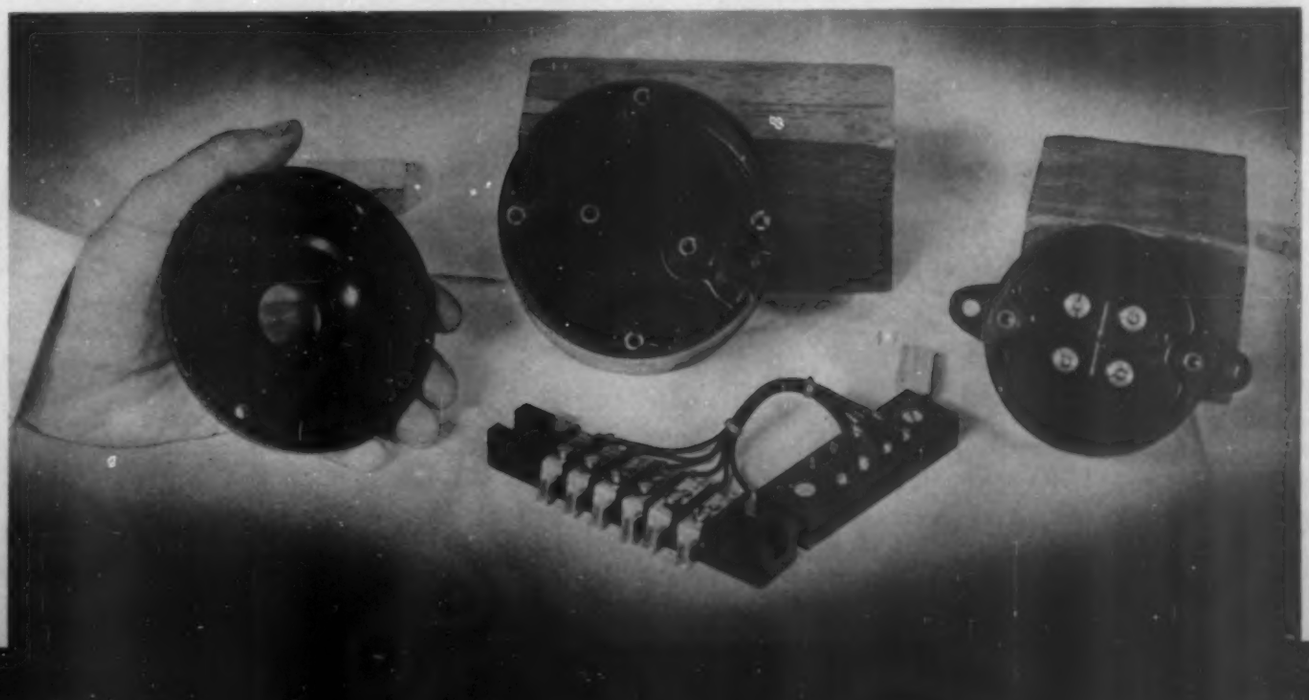
Since 1922, all phenolics used in the Navy for electrical purposes have been of the hot molded classification. In addition to some standardization as to quality of hot molded phenolics, two other things distinguish this six-year period above all previous periods in so far as electrical applications of plastics are concerned. One of these was brought about by the Disarmament Conference of 1922 which, by limiting the tonnage of ships which could be built, made weight saving of vital importance. As one small example of weight saving afforded by plastics, Navy connection boxes might be mentioned. Heavy brass compositions had been used for years in naval connection boxes, fittings, instruments, etc. To save weight, light aluminum alloys were developed.

Then phenolics were brought into the picture. They seemed to offer great possibilities but, through lack of adequate control of quality, could not at first be entirely trusted. One article might be splendid, while another one, looking just as fine as the first, proved to be about as dependable as a hunk of nicely colored mud. The fact that the weight of the phenolic was almost exactly half of that of any suitable light metal (aluminum) alloy continued, however, to be a most interesting one.

The light weight characteristic of molded phenolics was not the only incentive to their use. A still larger one was the fact that the material itself was inherently a good electrical insulator. Thus all the separate insulating bases previously used inside the heavy metal boxes to prevent electrical grounding could be dispensed with.

The second important development grew out of tests on flame resistance of phenolic insulation. All through the period of 1922–28 we had been engaged in making a large number of tests to determine the relative flammability of molded and laminated phenolic materials. Our difficulty in the development of a suitable flame resistance test was no doubt accentuated by the fact that we could not find enough actual difference between makes of materials to enable us to get our teeth into the problem. (*Please turn to next page*)

Replacing heavy brass composition for connection boxes and terminal strips are lightweight, shock- and impact-resistant phenolic molding compositions



An outstanding example of the all-important weight-saving qualities of phenolics is this inch gage (left) which weighs 1½ lb. as against the 7 lb. weight of the old metal model beside it. At right, molded phenolic connection plug

After many difficulties in testing flame resistance, I was asked to define flammability. When I attempted a definition, it was found that not only were my ideas on the nature of flammability different from those of others, but that practically no two persons had the same definition. Everyone was speaking a different tongue in this modern Babylon. All did, however, agree that a standard flame, or yardstick, was necessary. Such a suggestion, coming after six years of argument among many reasonably intelligent individuals, would seem to be too simple for words.

We soon found, however, that we could not produce a standard flame because not only did the source of the flame affect the flammable object in the flame, but the flammable object being tested backfired on the source of the flame with the result that each fire was in competition with the other. In short, one can only have a standard flame provided there is no flammable object in its path. Obviously, then, one could not use a standard flame to test a flammable object if it were necessary to keep the flammable object out of the flame. So the standard flame idea seemed to eliminate itself.

In order to avoid the competition between the thing which caused the burning and the thing whose burning was to be measured, we then decided that there could be no standard flame. We would have to place the flammable object under the influence of the same amount of heat that would have been generated had there been a standard flame. In short, something that was not a flame would have to do what a flame would do if it were there.

The simplest way to measure such a quantity and intensity of heat was to do it electrically, in terms of wattage input. The easiest method of applying the heat without flame was to heat a metal to the required degree of incandescence and yet have that metal resistant to oxidation at the temperature of incandescence. The proper way to apply that measured heat to the flammable object, then, would seem to be to surround the object in such manner that all parts of it would be at a uniform distance from the heat. At the same time, the heat should not interfere with air getting to the flammable object, or remove any oxygen from that air. A round rod seemed to be the solution.

Immediately after the round rod idea struck home, we lost all interest in flame tests as such. Electrical cables were round. Here we had been using phenolics as insulation and yet had never thought of them for cable insulation, although all of the usual electrical insulations on electric cable were so very much more flammable than any of the phenolics! We began to wonder why we should fool around with hairline distinctions when there might be some real cream waiting to be skimmed off a lot of milk. Besides, the tonnages of insulation on electric cables and the tonnages of electric cables on a ship were so much greater and far more concentrated in the ship than were the phenolic parts in use. If we so feared fire, why not look for its prevention in the large cable nests aboard ship? Words are funny that way: merely change a word and the picture changes so completely that we wonder why we ever placed the emphasis where we did.

So we promptly concentrated on electrical cable insulation. It was in 1928 that we reached this point. Up to this time, the principal plastics applications aboard ship were in the phenolic field. This was the turning point, and from here on other plastics began to acquire added interest. Here is where we started to define our objective instead of naming a specific material. That point is important.

Period of 1928 to 1932

This four-year period was spent in trying further to define objectives by the development of test methods. That is, we attempted to state the problems with which we were confronted, and to put them down in such technical terms and forms as would permit many minds to work together toward the same goals. This does not guarantee success, but it helps plenty.

We collected test methods and all the yardsticks we could find from textbooks, from various technical and engineering societies, from technical papers and from every source where we thought we might find them. We started to collect tests as a philatelist would collect old stamps, or a numismatist his coins.

The class of materials which merited the greatest amount of research and investigation along these lines were the components of electric cables, not only because of the fire hazard and the quantity of material involved, but also because of their simple geometric shape. The shape factor was important because we could test the material in its natural form instead of trying to change its shape to conform to some standard specimen size.

Flame tests and every other type of test that could be thought up were therefore applied to cable. A lot of cable was burned up in the laboratory. This is one case where we started so early and with so much that our start greatly softened the effect of the fall of Malaya and of the Netherlands East Indies. When they asked, "How much rubber?" we swelled up and retorted quickly, in soda fountain fashion, "Make ours plastics." And that retort goes not only for some rubber, but also for some aluminum, some tin, some tung oil (China wood oil), some silk and a few other critical materials.

During the early part of this 1928–32 period, however, progress was slow and irregular and the results conflicting because we had yet to learn how to measure.

Period of 1932 to 1942

By 1932 our ideas and means of measurement had at least crystallized to the point where some more definite attempts could be made to work out standards for many things. Such work, of course, involved very close cooperation among the Bureau of Ships, Navy yards, shipyards, the inspection force and the manufacturers generally. In fact, such work meant the very closest kind of cooperation with literally thousands of engineers and scientists employed by the principal electrical manufacturing concerns of the country.

As one example of growth in the use of plastics during this period, we might hark back to the matter of molded and laminated phenolics. Whereas we started out with only one molded (and no laminated) phenolic material, we wound up by standardizing nineteen types (seven molded and twelve laminated). Contrary to the usual conception of standardization (having fewer types), this growth in Navy types through the years simply indicated a growth in applicaton. Phenolics, like other plastics, are analogous to metal alloys in that different types, compounds, alloys, etc., are needed if various purposes are to be best served.

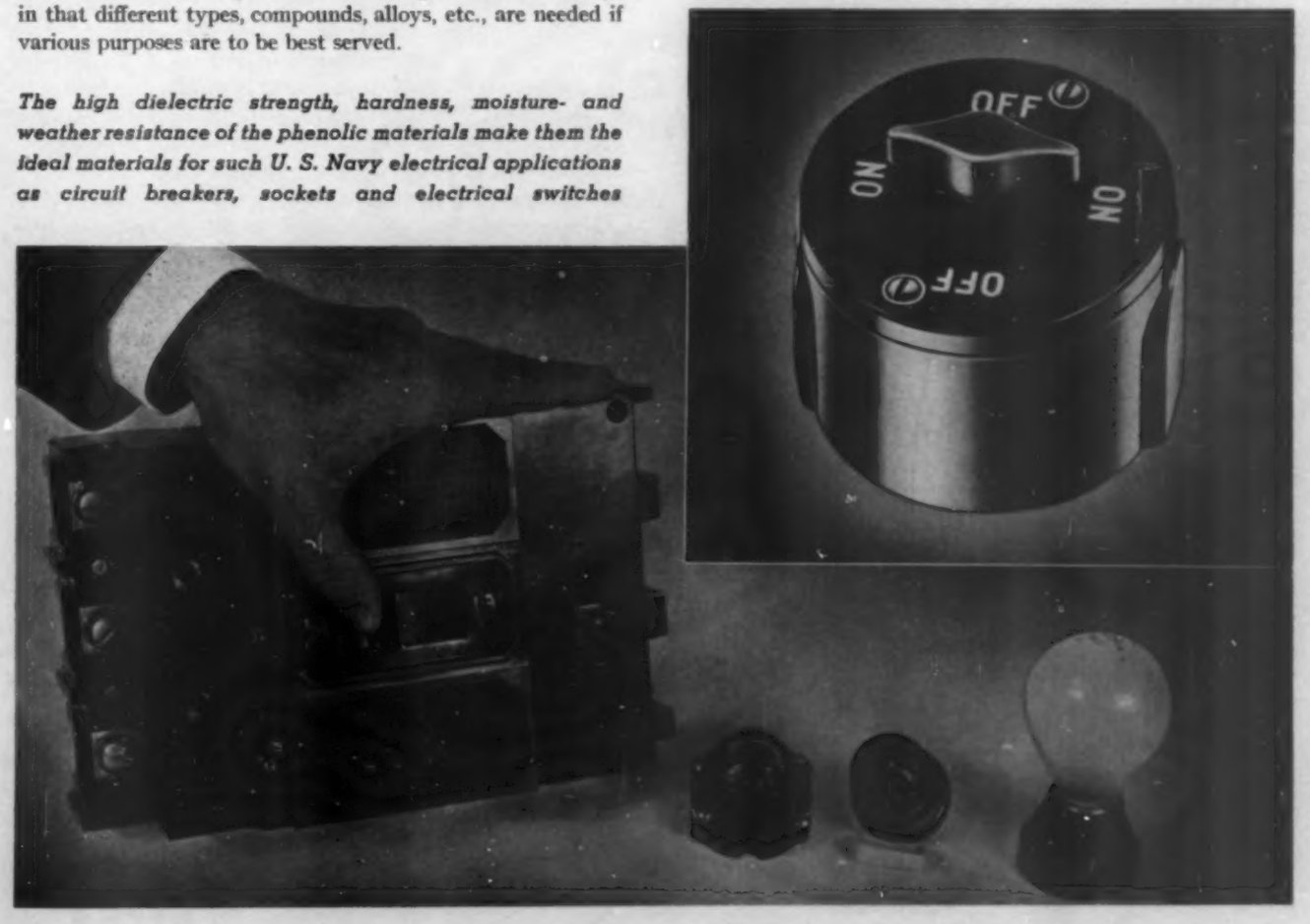
Insulating varnishes, one of the most basic of all electrical insulations, was another field in which considerable progress was made during this period. As an example of that progress, consider that in *1923* a black insulating varnish had a life of *50* hours at 105° C. In *1940* black insulating varnishes had a life of over *3500* hours at 105° C.

In place of the natural resinous products now so critical, we have the newer insulating cloths, tapes, tubings and sleevings, either alone (all-resinous) or in combination with inorganic materials such as glass or asbestos. These are not just substitutes for some of the things lost in the Far East. They are so much better than those we had to give up that we never will have to go back to the natural product again. Furthermore, they are made in America.

When it comes to switchboards and their structural members, we now obtain greater electrical insulation values and greater impact strength values by getting away from the materials previously used. In such cases, the plastic may even take the place of metal boards and structural and strength members.

Plastics of the transparent, translucent and colored types are now used in considerable volume for the heavy but fragile glass formerly used in electric lighting fixtures. They are also used in the mechanical construction of many such fixtures, fittings, appliances, etc. In some of these cases, plastics have replaced a part of the tin previously used. Another place where plastics have partially supplanted tin is in certain large water-lubricated bearings, which now employ laminated plastics in place of a tin alloy.

Transparent plastics are likewise employed as an added safety feature (to say nothing of the saving in weight) in the faces and dials on all sizes and (*Please turn to page 126*)



The high dielectric strength, hardness, moisture- and weather resistance of the phenolic materials make them the ideal materials for such U. S. Navy electrical applications as circuit breakers, sockets and electrical switches

Covering binocular bodies

by W. R. BAILEY*

PRESS ASSOCIATION PHOTO

WHETHER following the tide of battle on the high seas or on desert sands, the observer's eyes are no better than the binoculars he uses in detecting the enemy. Those binoculars must have a good gripping surface which will enable him to hold them firmly and comfortably. The surface must afford maximum protection for the binocular under severe heat, cold and weathering conditions if they are to have a long life of continuous service. Unless these features are present in the covering, the fine workmanship which has gone into the lenses is all to no purpose.

It may seem like a relatively unimportant item, but the rubber used for covering binocular bodies reaches an incredibly large figure when Army and Navy requirements are considered. So some months ago, the Joint Optics Committee called a meeting of the Army and Navy Munitions Board and representatives of the Army and Navy to present plastic substitutes and to discuss development work.

The first step toward finding the most satisfactory plastic replacement for rubber was taken last spring at the annual meeting of the Society of the Plastics Industry at Hot Springs, Virginia, when representatives of the Optics Committee and of the Naval Observatory presented briefly the requirements of a substitute for rubber in binocular covers. At that time, a meeting at the Naval Observatory in Washington was set for May 6, 1942.

At this meeting the needs for a rubber substitute were outlined in detail and were discussed with the representatives of 35 companies in the plastics industry. Manufacturers and molders agreed to submit samples of materials for test at the earliest possible date. Uncovered aluminum binocular bodies

* Ensign, U.S.N.R.; asst. material officer, U. S. Naval Observatory, Washington, D. C.

Experimental U. S. Navy binocular coverings failed of acceptance for a variety of reasons: 1*—Loosened sand from sand-finished phenolic abraded the lenses.* 2*—Cellulose acetate (E) embossed poorly; crackle finished, it wasn't abrasion-resistant*

PHOTOS, COURTESY U.S. NAVAL OBSERVATORY

1

2

were furnished the companies for experimental covering and for return to the Naval Observatory before May 23, 1942. A second plastics meeting was then scheduled for that date, when results of experiments could be displayed and beneficial suggestions could be offered for expediting the project and for solving the problems presented.

Binocular bodies covered with phenol-formaldehyde resin, cellulose impregnated cloth, cellulose sheet cover, cellulose dope, crackle lacquer paints and cellulose acetate butyrate were submitted. Other substitute materials were in the process of being developed.

The varnish type phenol-formaldehyde resinous coating submitted was thought to have many desirable qualities in-including the good gripping surface afforded by the sand finish. However, in producing the finished binoculars, the optical companies could not cope with the abrasion caused by loosened sand (see Fig. 1). Cellulose acetate material was found to be undesirable because of its low capacity for the embossing which is necessary to give the binocular body a good gripping surface (see sample E in Fig. 2). Cellulose acetate furnished in a crackle finish was also thought to be disadvantageous because of its poor resistance to abrasion (see sample F in Fig. 2). A cellulose nitrate covering applied to the binocular by dipping was found unsuitable because of the very smooth finish inevitable with such an application. Its explosive and inflammable qualities made it inappropriate for Navy use (see sample M in Fig. 3).

Several samples covered by spraying or painting tung oil in crackle finish were considered inadvisable because of lack of resilience, and the necessity of changing the design of the binocular bodies to accommodate such a thin coating.

When the plastic materials available had been inspected and discussed, tung oil lacquer with crackle finish, pyroxylin fabric backed coating, cellulose acetate butyrate and vinyl compounds which had been submitted or were being developed were chosen for further test. Since only visible inspection had been made at that time, it was impossible to determine whether or not a satisfactory covering had been developed. Intensive tests by the Naval Observatory and by the Bureau of Standards would reveal which material and application would be most suitable for covering binocular bodies.

Heretofore all materials which had a cloth backing were thought to be undesirable because they would allow the growth of fungi, but by this time a process had been developed for treating fabric against the growth of fungi. This process of treating material was tested at the Bureau of Standards and found to be satisfactory for use on these binocular bodies.

Injection molding with vinyl resin was unsatisfactory since at 140° F. it showed shrinkage (see Fig. 4). The artificial leather fabric with cellulose nitrate coating had a good appearance and withstood low temperature but showed shrinkage at 175° F. A high exudation material did not shrink but became sticky and remained that way even after normal temperature was resumed (see Fig. 5).

Hand-stippled cellulose acetate butyrate was submitted as a possible covering and was found to withstand accelerated weathering tests but, because of its irregular contour, the material was not further tested (see Fig. 6). Sample J in Fig. 7 shows the hard crackle-finish paint which, when subjected to extreme service temperatures and tested for cold impact, was found acceptable; but the material could be applied only in a thin coat and was nonresilient.

Tung oil lacquer finish sprayed to the body was tested at extreme service temperatures and found to chip (see Fig. 8) very readily at the lower temperatures and to soften to a great degree of stickiness at the higher ones, rendering it unsuitable for the purpose intended.

A sample of vinyl chloride-acetate copolymer plasticized

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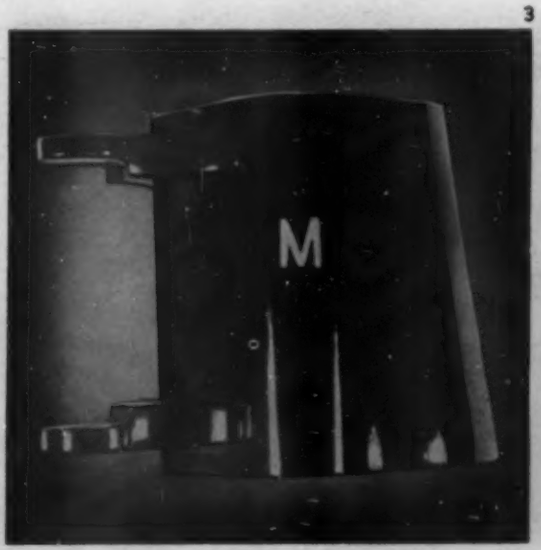

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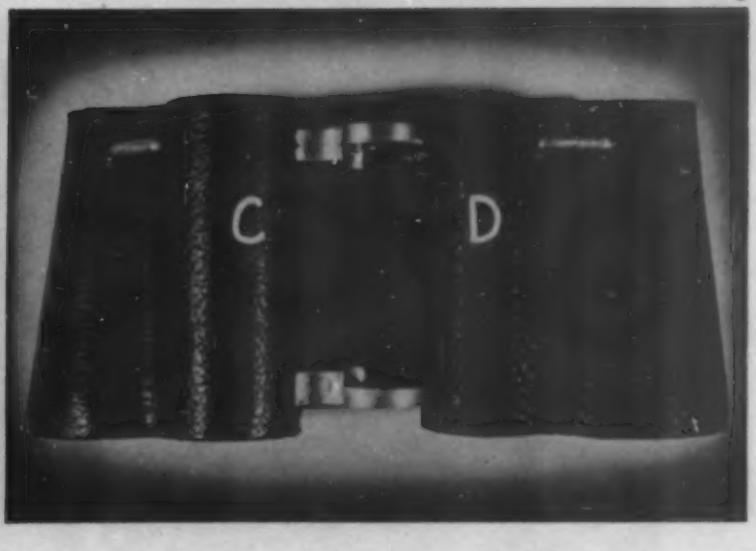

3—Cellulose nitrate applied by dipping gave too smooth a finish, was explosive and inflammable. 4—Injection-molded vinyl resin shrank at high temperatures. 5—So did artificial leather, cellulose nitrate coated; a high exudation material became sticky at high temperature, stayed that way

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sheeting, embossed and laminated to fabric, bonded to a binocular body by a specially developed plastic adhesive, withstood all tests previously made and met Bureau of Ships Ad Interim Specifications 33C8 (INT) for Organic Plastic Covering. However this sample contained very critical vinyl resins which could not be made available for this purpose. Since the optical companies supplying binoculars for the Navy were given notice in July that no more rubber could be allocated for binocular body covering, it was necessary that a readily available vinyl resin be developed to the point where it could match qualities with the approved vinyl resin. Accelerated research work among the material suppliers, the U. S. Naval Observatory and the National Bureau of Standards was begun. This research work resulted in the development of a plastic covering material having the same components as the original sample of vinyl chloride-acetate copolymer but in different proportions, avoiding the use of a strategic material. This new formula was found to produce a material which would meet the tentative specifications set up at the Naval Observatory.

A meeting of the optical companies furnishing binoculars for the Navy was held July 9, 1942, for the purpose of formulating plans for starting production of plastic covering for binocular bodies when the material had been fully developed for this particular use. The material suppliers were notified as to what plastic material could be allocated for this purpose. Tentative specifications set up at the Naval Observatory were explained in detail and material suppliers determined their fabrication procedures at this meeting. After the application of the adhesive had been explained, the optical companies felt that the bonding of the plastic covering material to the binocular bodies could be accomplished with relative ease. It was decided that the fabric backing should be thin and closely woven to promote flexibility, yet heavy enough to prevent the vinyl resin compound from permeating the fabric. Previous to the application of the vinyl resin the fabric would be impregnated with chemicals to prevent the growth of fungi. This process of impregnating the fabric would in no way affect the adhesive's bonding qualities.

6—Hand-stippled cellulose acetate butyrate had an irregular contour. 7—Hard crackle finish paint gave too thin a coating, was non-resilient. 8—Tung oil lacquer chipped at low temperatures, softened at high. 9—Four stages in development of vinyl resin compound finally accepted

9

Each optical company represented agreed to purchase approximately 100 sq. ft. of this newly developed material to be used in setting up processing equipment for pilot plant production of binocular-body covering. The material suppliers agreed to coordinate all efforts to meet this emergency at the earliest possible date, in order that the optical companies might have an adequate supply of an acceptable substitute for the old rubber covering.

Figure 9 shows the newly processed resin in its four stages of development, with varying amounts of plasticizer. These samples are unlaminated and unembossed. Sample Q was found to meet Bureau of Ships Ad Interim Specifications 33C8 from a material standpoint. The formula for these materials was used to compound and produce the finished material having fabric backing and embossed surface (Fig. 10).

The first test run producing finished plastic covering from the selected material was made July 29, 1942. The new material failed to meet specifications because of changes in formulation necessary to fabricate with embossing and fabric lamination. More research work was undertaken immediately to produce commercially a suitable covering. The second run with the newly developed material was made August 4, 1942, and revealed that this material would conform to Bureau of Ships Ad Interim Specifications and would be acceptable as a binocular covering as shown in Fig. 10. Each optical company manufacturing binoculars for the Navy was supplied 100 sq. ft. of this material. At the same time, research work was carried on to produce an adhesive for permanently bonding the plastic sheeting to binocular bodies. On August 6, 1942, the newly developed adhesive was tested as a bonding agent in the plant of one of the optical companies and found satisfactory. This material was then sent out to the same optical companies that received plastic sheeting. After approximately one week of actual plant production, a meeting of the material suppliers and optical companies was held for the purpose of discussing problems encountered in the application of the covering to the binocular bodies.

Six covered binocular bodies were submitted at that time, three of which had the fabric backing removed from the material. The unbacked material was found to be superior in that its degree of pliability was increased, its adhesion improved, and its elasticity increased to provide for slight variations in the size of binocular bodies. The depth of the embossing was found to be too shallow and the necessary steps were taken to provide deeper embossing plates.

Before bonding this material to the binocular body, the body must be primed with a coat of the adhesive and baked for approximately $^1/_2$ hr. at 275° F. The adhesive should be applied to the fabric side of the sheeting and allowed to dry completely by air at room temperature. The material must be activated with an additional coat of the adhesive and warmed over a lamp shade to increase its elasticity and pliability in application. After the covering has been applied, the binocular body should be warmed to 150° F. for approximately 1 hr. to drive out excess solvents, and heated to 190° F. for $^1/_2$ hr. to complete the bond.

Seams appearing where the ends of the material meet can be obliterated by the use of a heated pointed instrument and an embossing wheel. The pointed instrument should be drawn through the seam to heat-seal it. An oily cloth should be rubbed over the sealed surface for lubrication and the embossing wheel drawn firmly down the seam line, leaving it identical with the embossed material.

In assembling some types of binoculars, it is necessary to grind the edge of the material with a routing machine to insure close fitting of the cover plates. To obtain the best results, the body should be refrigerated prior to grinding or a stream of cold water should be applied to the edge being ground. In finishing the covered body, it should be sprayed with an approved vinyl paint and baked at a temperature not to exceed 195° F. The binocular will then be ready for the assembly of its optics and ultimate service use.

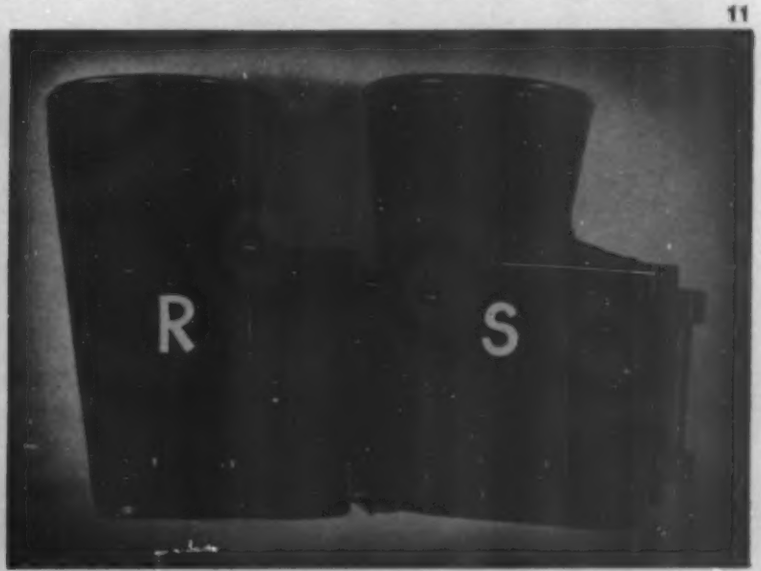
Figure 11 shows the rubber-covered sample, R, which is now being used and the newly developed plastic covered sample, S, with which the optical companies will go into mass production in the near future.

The plastic covering is superior to rubber in that it affords a better gripping surface, is more resilient, and will have longer life because of its ability to withstand severe weathering conditions and its resistance to abrasion. The cost both of the material and of the application of it is nearly the same as that of rubber. The material suppliers are continuing research until all production problems have been eliminated and uninterrupted production can be carried on.

10—Fabric-backed and embossed, the vinyl material conformed to Bureau of Ships specifications. 11—Rubber-covered binocular body now in use (R) and a sample of the vinyl resin covered body (S) scheduled to go into production soon

10

11



PRODUCT DEVELOPMENT

Airplane control knobs

Nose, gun turret, fuselage, wing section or control knobs—for the largest as well as for the smallest airplane unit, there is a suitable plastic material available. Here are a variety of injection molded ethyl cellulose control knobs and levers in different colors which are going into present-day aircraft construction.

A high degree of electrical resistance, toughness, low temperature flexibility, stability to heat, impact resistance and low moisture absorption are all properties which make this material an ideal choice for airplane parts.

The knob is injection-molded in two pieces with a hollow center which results in a final assembly that is lighter in weight than it would be if made by any other method or with any other material. The inherent color of the plastic material itself eliminates the necessity for any painting or finishing operations, and gives each control function a different colored knob so that prompt and accurate identification of each can be made in emergencies.

The knobs are riveted directly to the lever arms, an operation which replaces the old method of turning and threading, thus reducing assembly costs appreciably. Earlier materials were unsatisfactory because the parts cracked during the process of heading up the rivets. The switch to ethyl cellulose overcame this difficulty.

Credits—Material: Ethocel. Molded by Amos Molded Plastics for Beech Aircraft Co.

Methacrylate models

Plastics are taking a hand in training for war. Translated into the three-dimensional terms of transparent, light-catching methyl methacrylate plastic models, problems of mechanical drawing, of die and tool design, of naval architecture and ship operation become amazingly clear.

Models of technical drawing problems constructed from this transparent plastic material reveal at a glance, in any projection and from any perspective, the intricacies of angle and plane formations which perplexed students previously had to gage from opaque models or flat diagrams.

In courses teaching die design and construction (see photograph) methyl methacrylate sheet is proving an invaluable asset. Transparent models reveal the function of every moving part during a stamping operation. In tool design, fundamentals of complex jig and fixture construction are laid bare by this medium.

The output of six work units of craftsmen under the sponsorship of the Extension Service of Pennsylvania State College is going principally to centers maintained by the Engineering, Science and Management War Training Program conducted in various colleges throughout the U. S.

For the construction of these plastic models, methacrylate sheets can be sawed and drilled with tools similar to those used for wood or metal, or can be heated and bent to any curved shape.

Credits—Material: Plexiglas.

PRODUCT DEVELOPMENT

Short-wave diathermy

Most therapeutic equipment is expensive, and doctors who buy it expect it to last a long time. For that reason, manufacturers select materials that are durable and of good quality for such intricate mechanisms.

The young woman at the right is receiving a short-wave diathermy treatment from an electromedical unit which contains a group of molded plastic parts that will stand up under constant wear and tear. The electromagnetic circular induction drum and the electrostatic air-spaced disks which are interchangeable with it, together with the output terminals, pilot light bezels, control knobs and meter case on this instrument are all molded of a high-impact phenolic material.

Great strength, shock-resistance, heat resistance, and exceptional insulating properties are all characteristic of this type of thermosetting plastic material; and all are required in the component parts of a machine like this Challenger Model G, the function of which is alleviation of pain and treatment of disease through application of heat from high frequency currents.

Aside from adding to its safety of performance and efficiency of operation, the phenolic material contributes to the handsome compact appearance of the mechanism. The manufacturer of the diathermy machine is reported to be considering plastics for parts of other electromedical equipment now made of strategic or hard-to-get materials.

Credits—Material: Durez. Manufacturer: Birtcher Corp.

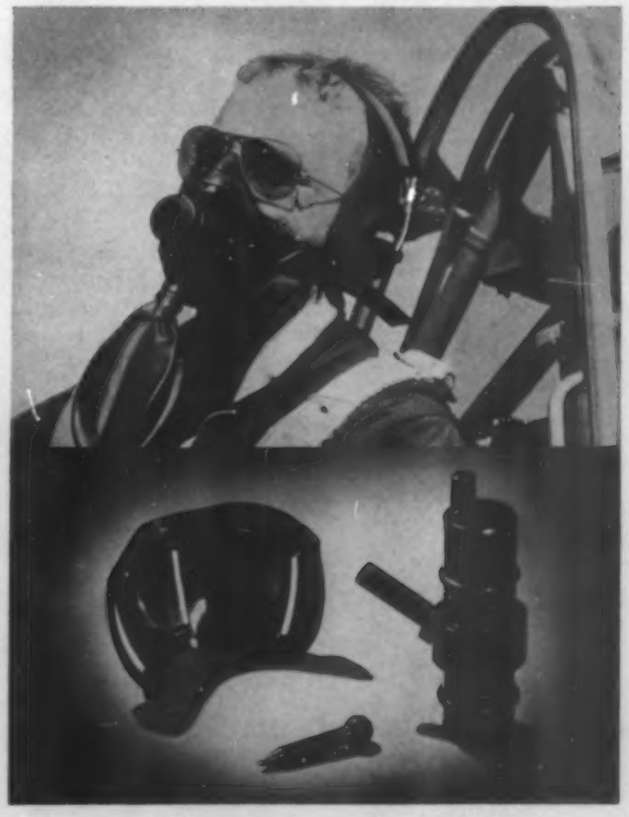
Oxygen mask

Up and up, beyond the atmosphere, into the substratosphere, and as the plane gains in altitude the problem of feeding the pilot an even, reliable flow of oxygen becomes increasingly important. The solution to the problem lies in this lightweight, skillfully designed B-L-B Sub-Strato Mask, which has been adopted by the U. S. Army Air Corps.

Built of a specially compounded rubber which will not harden in low temperatures at high altitudes, and a special lightweight, heavy duty phenolic formaldehyde molding composition, this mask has been designed to conform to the underlying bony structure of the face. The use of the unit is described by the manufacturer as affording an exceptionally high degree of comfort at high altitudes, and a saving of 75 to 80 percent of oxygen. The smooth material provides excellent surface contact with the face at every point, and is practically free from pressure strain even when worn for protracted periods. In its working mechanism there is no metal to freeze to the pilot's face, no moving parts to ice and stick.

The saddle, connector and plug of the mask (left to right in the lower photograph) are all molded of phenolic, selected because it is light in weight, durable, and relatively impervious to moisture and weather changes likely to be encountered at high altitudes.

Credits—Material: Resinox. Molded by Minneapolis Plastic Co. for Ohio Chemical & Manufacturing Co.



LT. COMMANDER RALPH O. PHILLIPS

FRED CONLEY

THOMAS S. CARSWELL

S.P.E. convention at Detroit

MORE than 150 members and guests attended the late summer meeting of the Society of Plastics Engineers held on September 18 in the Horace A. Rackham Educational Memorial Building, Detroit, Michigan. President Fred Conley presided at the dinner session of the meeting where Lt. Commander Ralph O. Phillips, Bureau of Ordnance, U. S. Navy, was the featured speaker.

The Commander's remarks, which contained much information of interest to those in attendance at the meeting, and to plastics men in general, were substantially as follows:

Our Navy has been in the plastics manufacturing business for many years and is a very old user of an important plastic. I refer to *smokeless powder*. In fact, long before World War I we built our own factory for the manufacture of this plastic product and thousands of tons are now being used annually by your Navy in these days of war, from ships, bases and outposts spread over almost the entire earth's surface. I say bases and outposts, for the Marine Corps from a functional standpoint is a part of the Navy.

After and immediately following Pearl Harbor, our countrymen on the whole failed to realize that the United States Navy was plunged into the greatest naval war of all history. With a one-ocean Navy, we were called upon overnight to fight not on one ocean or on two, but on the seven seas of the earth.

What that implies is tremendous. There is no precedent for a sea war on the scale of this one. This is *global* war—a new concept. To win complete control of every foot of every sea the world around—this is the Navy's aim and responsiblity together with that of our valiant allies. To control, as well, every foot of skies above these seas—this also is the Navy's goal—and we shall do it. It is the Army's job to fight this war on all the five continents of the world. But to see that every soldier and every scrap of material land on all the continents, and to maintain huge and constant streams of supplies to American outposts after the troops are there—this is the Navy's responsibility. To build up new bases from trackless jungle to full operating efficiency, bases with facilities to supply and repair whole fleets, bases to be used as jumping-off places for future offensives—this also is the Navy's responsibility. To design and rush the construction of new ships by the hundreds; to design and supervise the manufacture and testing of all guns, depth charges, torpedoes and other equipments; to recruit and train a million officers and men, including 30,000 Navy pilots a year; to protect every foot of the 16,000 miles of coastline of the United States and her possessions—these, too, are among the Navy's responsibilities. It is a task without precedent in the history of war.

How is the Navy winning this war and what tools does the Navy have available to do the job?

The answer is that, although we entered this war with a one-ocean Navy, we are now building the largest Navy the world has ever seen—a Navy which, when completed, will be larger than all the other Navies of the world combined. As I speak here at this moment, we have the largest and strongest Navy in the world, and it is expanding as fast as human beings can fashion ships and guns.

I hate to think of the spot we would be in if the present stupendous building program hadn't been begun years ago, when President Roosevelt first came into office. Even so, the fleet with which we entered the war on December 7 was stronger by only 350,000 tons of combat tonnage than the force with which we entered the first World War in 1917.

Such a statement, however, does not do justice to the progress that has been made. The Navy building program was in full swing and gaining momentum when we entered this world-wide war, and joined our allies to help defeat the devil and all his works. *Every year* since 1939, we have laid

down a greater tonnage of Navy ships than in the entire 17 years from 1922 to 1939. Three months before the Japs attacked, contracts had been awarded for every vessel authorized under the once-sensational two-ocean building program. When we entered the first World War, we had less than a half-million tons of *combat ships* under construction. When we entered this one, we had more than two million tons of *combat ships* on the way.

On December 7, 1941, our Navy, which includes combat, auxiliary, patrol and other vessels, totaled 942 ships. This does not count 861 other small craft used for local activities around naval establishements. All these we had in commission. Also on December 7, we had 936 combat, auxiliary and patrol ships building. *Since then*, the whole program has been stepped up again and again. Not only has the previous program been stepped up, but the Congress has authorized construction of an additonal 1,900,000 tons—500,000 tons of carriers, 500,000 tons of cruisers, and 900,000 tons of smaller ships.

This means that large numbers of new contracts have been let, above and beyond what was thought a year ago to be the maximum for the facilities of the country. New yards and ways have been built. Abandoned yards have been called into service and re-equipped. Facilities have been called upon no matter where they were located, even far from the sea. Navy ships are being built at Pittsburgh and launched into the Ohio; at Albany and launched into the Hudson; and at Denver, Colorado, and "launched" onto freight cars.

Peacetime delivery schedules have been scrapped. Speed is the watchword. The Navy's own shipyards, and most others as well, are on a 48-hour basic week, and a three-shift, 24-hour day. Duplicate designs are used wherever possible. To cut red tape, authority for making decisions regarding minor changes and methods has been decentralized to local Navy supervisors. Experience gained ever since 1933 has been put to work. Production line methods have been adopted wherever feasible. As a result, speed is no longer an aim today but a reality.

The Air Arm of the Navy, already the finest in the world, has been expanded at an even greater rate since war began. The United States is turning out 60,000 planes next year, and 125,000 the year after that. Of these an impressive share will go to the United States Navy, both for our carriers and for our shore bases.

I want to add that we are not only building a *large* Navy—we are building a *balanced* Navy. We have battleships, because they, and especially the new ones such as the great *Iowa* launched the other day, are still the hardest-hitting, toughest ships afloat. We have aircraft carriers, because they have proved to be the most useful weapon of sea warfare in World War II. We have cruisers, the fast, dangerous craft that are so ideal to cover hit-and-run raids, protect an aircraft carrier in a task force, mother a convoy, or wreak havoc with enemy shipping. We have destroyers, the ever-present jacks-of-all-trade for almost any dirty work to be done. We have submarines, far-ranging, deadly undersea raiders to cut the enemy's supply lines on which his every success depends. We have sub-chasers, speedy, light-draft little watchdogs designed specifically to hunt down our enemies' submarines off our own coasts. We have many, many other types of ships and many weapons, new and old as well, for the Navy has many, many jobs to do.

Now let us look at some of these myriad activities of our wartime Navy in more detail.

The first, of course, is to engage the enemy in combat. The ultimate aim of fighting ships is to fight. Only thus can the final decisions be won. We all know of the victories of Midway and the Coral Sea, a blow from which Japan will never fully recover. The Solomon Islands—a perfectly planned and executed landing operation of the Navy and the Marines, working together. These major fighting engagements do not include the spectacular individual sinkings by our motor torpedo boats, nor by our submarines.

How about the Navy's other jobs? Let us take convoying. Can any man here, regardless of the mathematical grasp of his mind, conceive of the tremendous job of convoying? American troops stand poised in Ireland, ready to lunge at the European Continent as soon as guns and planes enough are massed. American troops hold the bleak tundras of Iceland and fight side by side with the British on the African desert. American troops tramp the streets of Melbourne, man the anti-aircraft guns in (*Please turn to page 128*)

PHOTOS, COURTESY "THIS WEEK" MAGAZINE

Process sunset is projected on transparent plastic screen by cameraman in rear

Seeing is believing

by KATHRYN SAILE

Hollywood and the movie industry have succeeded in overcoming the limitations of priorities by using improved plastic screens for process stages

HOLLYWOOD, fabulous city of a thousand faces, where make-believe is the chief commodity, and "super colossal" is a term of the mildest approbation, has solved one of its problems with the aid of plastic materials. The movie industry, purveyor of the ultimate in unreality, has always—strangely enough—scorned any but the most realistic effects. Elaborate three-dimensional sets, days in the making, were constructed with "expense is no object" abandon for a sequence that might run 40 seconds in the finished opus, or might even be eliminated entirely. And then came the war with its impact on the humble and the mighty alike. Priorities, labor shortages, travel restrictions, rubber, aluminum, steel, were ominous terms whose significance began to be felt all over America, not least of all in Hollywood.

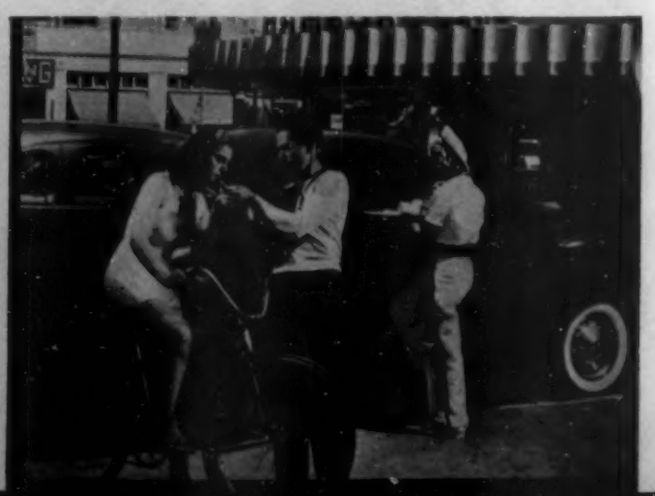
Producers, technicians, yes-men, all searched feverishly for a solution to this pressing problem, and emerged finally with a triumphant new wrinkle to an old Hollywood trick—the process stage. The process stage makes it possible for a producer to take a photograph of a scene—the Sahara Desert, the East River, Yellowstone Park—and project this picture onto a semi-transparent screen to create a background for the actors. They may even photograph a picture of something and project that onto the screen (Figs. 2, 3).

This background screen, formerly made of heavy plain glass, sandblasted or etched for diffusion, is now fabricated from translucent plastic. The glass screens, aside from being dangerous, cumbersome and fragile, presented the added difficulty of the "hot spot" caused by a falling off of the light. On a 12- by 18-ft. glass screen, light falls off from 40 to 60 percent from center to edge, making the glass unsuitable for rear projection use. Because of heavy grain and refraction of light, loss of halftones and poor definition may also be traced to the use of a glass screen.

The plastic screen is a seamless unit, tough, flexible and flameproof. It is easily rolled for shipment; and if it becomes soiled or fingermarked, a simple soap and water treatment will leave the finished surface as good as new.

From the camera side the (*Please turn to page 124*)

Boy meets girl on movie set with only a blank wall for background. With the aid of the process stage (right), they are transported in a flash to a busy roadside refreshment stand, realistic, convincing and time-saving



Printing with thermoplastic plates

by E. A. WILLIAMSON*

HEADLINES in the daily press have been sounding a warning to the printing industry that the metals so necessary to its normal functioning are growing increasingly scarce. Recently, Government spokesmen have even been indicating that lead may become difficult to get.

Printing with plastics

An important new printing development that aids urgently needed conservation of metals is a thermoplastic material and process developed by the Printing Materials Division of Bakelite Corp., Unit of Union Carbide and Carbon Corp., for the making of plastic duplicate printing plates. These plates may be used to replace electrotypes and stereotypes in many printing applications, thereby conserving strategic metals such as copper, zinc, tin, antimony and lead—all subject to present or prospective shortage.

The new plates are entirely made of a vinyl resin, yet they are apparently capable of meeting or surpassing the standards set for metal plates employed in a wide range of service. While this particular development is relatively new, its origin dates back 31 years and is the result of the company's continued research and development in applying plastics to the printing industry.

Fidelity of reproduction—Printing plates molded from this new plastic material meet all requirements of work up to 175-line screen. Likewise, every demand of exacting register on most color work can be satisfied. This fidelity of reproduction is due to the exceptional dimensional stability characteristic of the base material.

Plates may be curved—Due to the fact that the printing plate material is such a recent development, plates made of it have as yet been used chiefly on flat-bed presses. Preliminary tests, however, indicate that they can be adapted readily to cylinder press work. When the plastic plates are employed for rotary printing, they will demonstrate many advantages. The light weight of these plates is a definite asset. Being thermoplastic, they can be readily rendered pliable when subjected to elevated temperatures and, therefore, they can be easily bent to conform to the cylinder and allowed to set by cooling in the curved shape. Vibration, caused by the centrifugal action of the metal plate on rotary presses at high speeds, is greatly reduced. Many disastrous accidents in the printing industry have occurred when heavy metal plates tore loose from cylinders of high-speed presses

Economy and convenience—The hardness and durability of the printing surface permits runs comparable with the number of impressions obtainable from the average copper

* Printing Materials Div., Bakelite Corp., Unit of Union Carbide and Carbon Corp.

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1—Lightweight, efficient plastic printing plates are helping to tide the printing industry over a difficult metal shortage emergency. Here a coat of graphite is applied to copper engraving in first step of plastic printing plate production. 2—The metal pattern is placed in the press and covered with a sheet of thermosetting matrix material. 3—The press is closed for 10 minutes while the resin sets and the impression of the original metal pattern is fixed in the surface of matrix

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electrotype. Runs of 75,000 to 100,000 have been achieved, and there are indications that runs as high as 300,000 to 400,000 can be obtained under ideal printing conditions.

Since the finished plate, 1/16 of an inch thick, weighs only 1/8 as much as a conventional electrotype or stereotype plate of the same area, the plastic printing plates can be handled and stored much more economically and conveniently than metal plates. This lightness in weight is also a distinct advantage from the standpoint of reduced shipping costs.

The United States Government found in this feature the answer to a problem which until recently had seriously complicated its Latin American relations. The U. S. Coordinator of Inter-American Affairs discovered that distribution of photographic news stories in the form of the usual stereotype mats to our Latin American neighbors was badly handicapped by the fact that many small South American newspapers lack stereotyping facilities. Furthermore, shipping actual stereotype plates or electrotypes by air mail would involve excessive costs. On the other hand, the new plastic printing plates, being so much lighter, conserved shipping space and costs. So, after thorough investigation in collaboration with the U. S. Government Printing Office, it was decided to send the new printing plates, made of plastic printing plate material, the lightness of which compares so favorably with stereotype mats. These plates are made in the U. S. Government Printing Office Plant, and in several contracting plants as well.

No corrosion—Many printers and others storing electrotypes for lengthy periods have at times suffered material losses and have been put to much trouble by corrosion of the

***4**—Printing plate material may be either in granular or sheet form. Here a thermoplastic powder is spread on the matrix.* ***5**—Thermoplastic backing sheet is placed over the powder before the assembly is put into the press.* ***6**—Insulating panel is placed over matrix and molding powder, and the whole unit inserted into press where it is subjected to heat and pressure for 3 minutes.* ***7**—Here the assembly is placed into a chilling press where light pressure is applied for one minute.* ***8**—The finished plate is pried off the matrix and is almost ready for use.* ***9**—In a final operation, the plate is trimmed, and may be either beveled for patent base, or nailed to a wooden block*

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plates in storage. This cannot happen with duplicate plastic printing plates, which are practically immune to attack by most acids, alkalies and other chemicals, organic and inorganic.

Production equipment and technique

The process of making printing plates with the new plastic material is simple. Equipment required consists of:

1. A rigid, accurately built hydraulic press, having either electrically or steam heated platens, and capable of exerting and maintaining a pressure of 1200 lb. per sq. in. on the working area.
2. A lightly built, inexpensive "chilling" press, which consists of two parallel platens, water-cooled, and actuated by a screw mechanism.
3. Trimming and beveling equipment.

There are two steps in making duplicate printing plates. First, it is necessary to have a matrix made from the original photo-engraving, zinc etching or form of type matter to be produced. Secondly, the plastic printing plate is molded in the matrix.

The matrix—The matrix material used has been on the market for some years. This matrix sheet has been successfully used in rubber printing plate molding and has been approved for such service by many leading plate makers, printers and paper converters. The material is supplied in sheet form and is of the thermosetting type. The matrix sheets are made in a number of sizes and types appropriate to various service requirements.

Technique—The molding press plate platens are operated at 300° F. The original metal pattern is placed in the press and covered with a sheet of the appropriate matrix material (see Fig. 2). Through a simple manipulation, the press is closed until light pressure is established between the matrix sheet and metal pattern. After a few seconds the resin in the matrix sheet has softened sufficiently to permit the metal pattern to be pressed into it. This is accomplished by increasing the pressure. The press is held in closed position for 10 minutes (see Fig. 3), during which time the resin polymerizes or "sets," fixing the negative impression of the original pattern in a smooth, hard matrix surface. The matrix has become permanently hard and is now ready for use. The entire operation can be completed in about 15 minutes. The matrix itself may be used many times and can be stored indefinitely without deterioration.

The printing plate—The plate material is supplied in the form of granular powder or in sheet form, depending upon service requirements. Production of printing plates from this material is even more simple than making the matrix. It softens readily when heated and becomes hard and tough when cooled. Unlike the matrix material, it is thermoplastic and can be resoftened by heating. This property is necessary to permit the plate to be subsequently curved if the user so desires. In making the plate, the press should be heated to 260° F. No higher nor lower temperature should be used. The matrix face is first coated with a special lubricant, and if the granular powder is employed, it is distributed over the surface of the matrix (see Fig. 4). The assembly of the matrix and molding powder is placed in the press and covered with an insulating panel (see Fig. 6).

The press is then closed to firm contact and held in position for 3 minutes, during which the material thoroughly softens. Pressure is applied, forcing the softened plastic into the cavities of the matrix. This does not require over 1200 lb. pressure per sq. inch.

When the plate is formed, the press is opened immediately and the entire assembly, including the top insulating panel, is transferred to a chilling press (Fig. 7) where a light pressure is applied for one minute. The plate is now hardened and may be removed from the matrix (Fig. 8). It can then be trimmed (Fig. 9) and either beveled for patent base, or nailed to a wooden block. Thickness of the finished plate is predetermined by the use of steel thickness bearers between the platens of the press. These bearers are placed outside the working area.

Inasmuch as the plastic printing plates are affected by some solvents, patented plate washes should not be used. Instead, kerosene or carbon tetrachloride are recommended.

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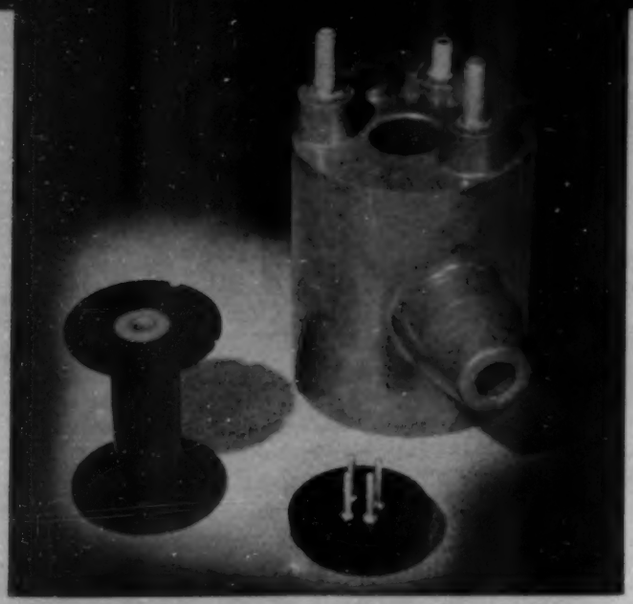

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plastics in review

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1 Various uses of plastics in industry are illustrated by this group of important industrial units. The radio tube base (right) is transfer molded of Bakelite in a two-cavity mold. Tolerances are held to plus or minus .002 in. on diameter for this application. The Bendix radio coil form (left) was transfer molded of Durez. The $^1/_{64}$-in. walls had to be molded so precisely that iron insert would fit without weakening them. The coil case for an aviation engine, compression molded in a four-cavity mold, has been skillfully designed so that inserts won't bend. All items molded by American Insulator Co.

2 Good electrical and mechanical properties combine to make Lumarith a suitable material for these Barker & Williamson induction coils, where this plastic is employed at four different radial points for insulation. These induction coils can be used for tuning any radio frequency circuit for transmission or reception, and all sizes from $1^5/_8$ in. in diameter by $2^1/_8$ in. long up to 1 in. in diameter by 2 in. long, use this cellulose acetate plastic for insulation

3 Tons of sorely needed metals for war industries are being released for active service by the use of cellulose acetate plastics (based on Hercules cellulose acetate flake) in the manufacture of these plastic plumbing fixtures. Molded by Precision Molded Plastics Co., and distributed by Magnetic Plastics Co., these parts have been designed to conform to the measurements of similar items formerly made of brass so that they fit into the general setup of other plumbing parts. Finish and color are inherent in the material

4 Nothing but the best is good enough for our Armed forces, even to the nonmilitary toothbrush exemplified by this U. S. Army specimen with a sturdy handle molded of Tenite II. Manufactured by Owens Staple-Tied Brush Co., these toothbrush handles are moistureproof, weather-resistant, and tough enough to withstand good hard use. Toothbrush boxes are molded by Insel Co. of the same cellulose acetate butyrate

5 Accurate and speedy testing of aircraft engines as they roll off the assembly line is the important function of this manometer, which records the amount of air entering the carburetor of the engine in terms of thousands of pounds per hour. Manufactured by Builders-Providence, Inc., Div. of Builders Iron Foundry, this instrument has a film of rigid, 0.040-in. clear Vinylite sheet to protect the delicate glass tube from breakage. Vinylite was selected because of its toughness, nonflammability and resistance to oil and grease

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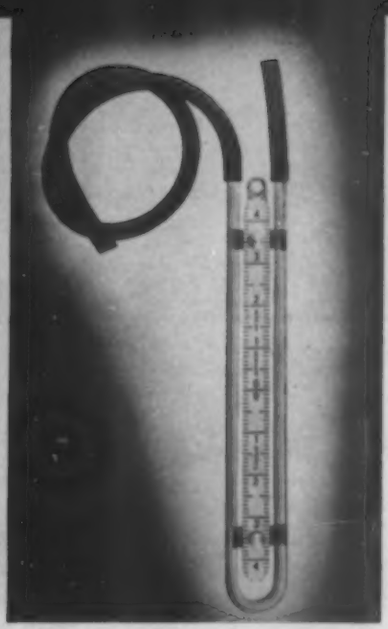

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6 The Compleat Angler, 1942 version, pursues his pleasure with a fishing rod that is equipped with a sturdy, water-resistant Ethocel handle. Molded by Superior Plastics, Inc., for the Richardson Rod and Reel Co., the handle is molded in one piece in a two-cavity mold, with the material molded around the insert. The fore-grip is molded in a separate die and attached after the handle is completed. A cork grip is attached for final assembly, and the only finishing operation required is buffing and gold stamping of the company trademark

7 Built to withstand rough service, this manometer is one of the first models to feature an unbreakable, heavy-wall Pyralin U-tube to hold water as the indicating fluid, and is said by the manufacturer to be unusually rugged and sturdy. Manufactured by the Trimount Instrument Co., this unit is used primarily for measuring pressure in air and water lines—small differential flows in water lines of low pressure, pressure in air conditioning ducts, and similar assemblies. A special lithographed metal scale attached to the U-tube is adjustable up or down so that the zero in the scale can be placed directly opposite the mercury or water level in the tube. Calibration in inches and tenths

8 Get a good grip, and you're off like the wind on a Harley-Davidson motorcycle equipped with Lumarith E. C. (ethyl cellulose) motorcycle grips. Tough, resilient, weatherproof, these grips made from a plastic material replace rubber for the duration

9 Delicate drill heads, especially important in the manufacture of military equipment today, are protected against shipping and storing hazards by transparent strips of Pyralin. This tough pliable cellulose nitrate material is fabricated into lightweight, rigid units that hold 12 drills of the same size (drills with large heads are packed in reverse), making possible a neat and compact packing assembly with maximum protection for the valuable implements. Boutwell Owens & Co., Inc., manufacture the packages for the Norton Co.

10 These brake linings, clutch facings, and fan belts from the Raybestos Division of Raybestos Manhattan, Inc., illustrate friction where it will do the most good—in friction material. Bonded with Durez resin (which also contributes to the frictional character of the units), these items are indispensable constituents of automobiles, buses, airplanes, farm and industrial equipment, where the coefficient of friction determines the rate of stopping with a given amount of force. Resistance to wear, stability of friction, hot and cold as well as wet and dry, silent action, freedom from scoring drums, good pedal feel, no odor, slight loss of reserve under severe usage, and good mechanical strength, are all qualities which characterize this friction material

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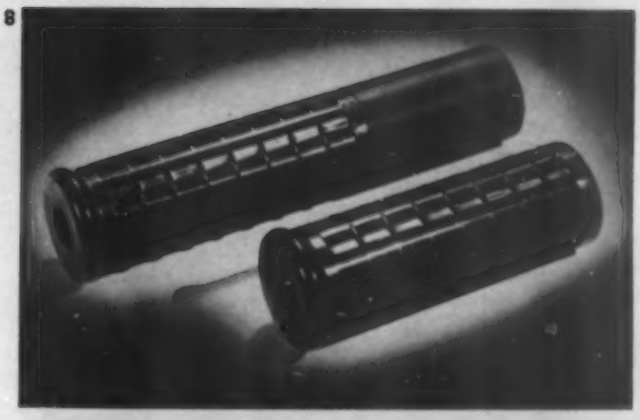

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Old light in the new dark

by M. A. WEIL*

BACK in Bologna in 1602, a little cobbler named Vincentius Casciarolus searched frantically for the alchemistic combine that would produce gold. He never found gold, but millions of stumbling, groping persons in today's blacked-out countries owe him a debt of gratitude. For out of Casciarolus' retorts and chemicals came the first reported inorganic phosphorescent substance to be produced artificially.

Thus luminescents are as old as blackouts are new. But the combination of the two has brought new attention to luminescent pigments. In England during the first 15 months of the war, when blackouts were still strange and unfamiliar, there were 3141 more deaths from highway accidents than during the preceding 15 well-lit, peaceful months. Then luminescents began to be used, and the accident death rate dropped nearly to normal. Clearly visible to motorist and pedestrian, phosphorescents have the advantageous property of being invisible from a plane flying at 20,000 feet.

The many substances that exhibit luminescent effects fall into three principal classes:

1. Radioactive pigments
2. Fluorescent pigments
3. Phosphorescent pigments

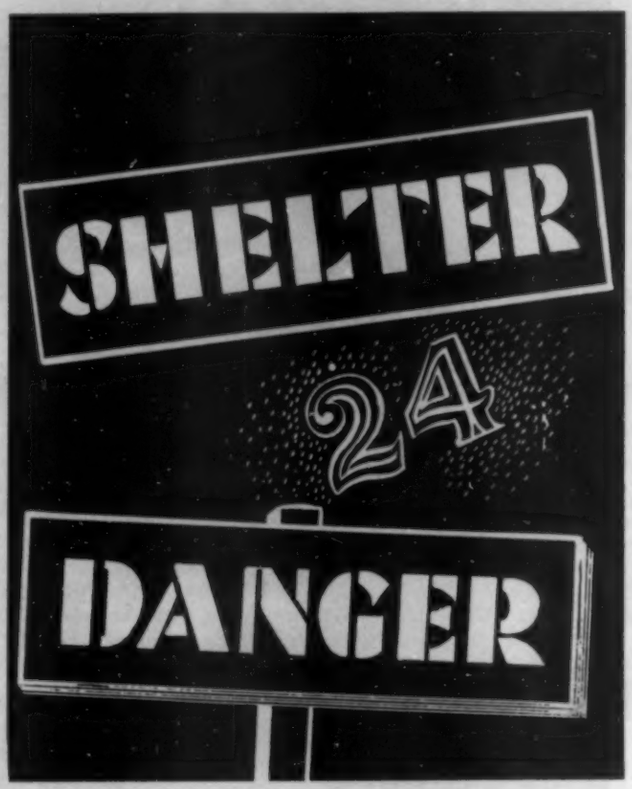
Radioactive pigments are caused by a small amount of radium salt bombarding especially prepared crystals and thus producing tiny sparks of light. If a sufficient amount of radium is present, the number of sparks is so large that the eye gets the impression of a steady glow. Because no further outside agent is necessary and the life of radium is long, the effect is self-lighting and permanent. This type of pigment is mainly used on dials of watches and instruments. It is too expensive for large surfaces and also too dangerous to handle.

Fluorescent pigments and dyes are visible only when they are excited by ultraviolet light rays. This so-called black light is difficult to maintain on objects in motion and vanishes if the electric power fails. Since fluorescent dyes and pigments produce very colorful effects, they are used extensively in the theatrical field. Their increased wartime applications are generally of a confidential nature.

Phosphorescent pigments are probably the most widely used for blackout purposes because they glow in the dark without the use of ultraviolet rays. They give off light that they have stored from previous exposure to ordinary daylight or fairly strong artificial light. This glowing, seen only in the darkness, is called afterglow, and lasts for several minutes or several hours depending on the chemical nature of the substance, the care taken in its manufacture, and how the pigments are applied to the finished product.

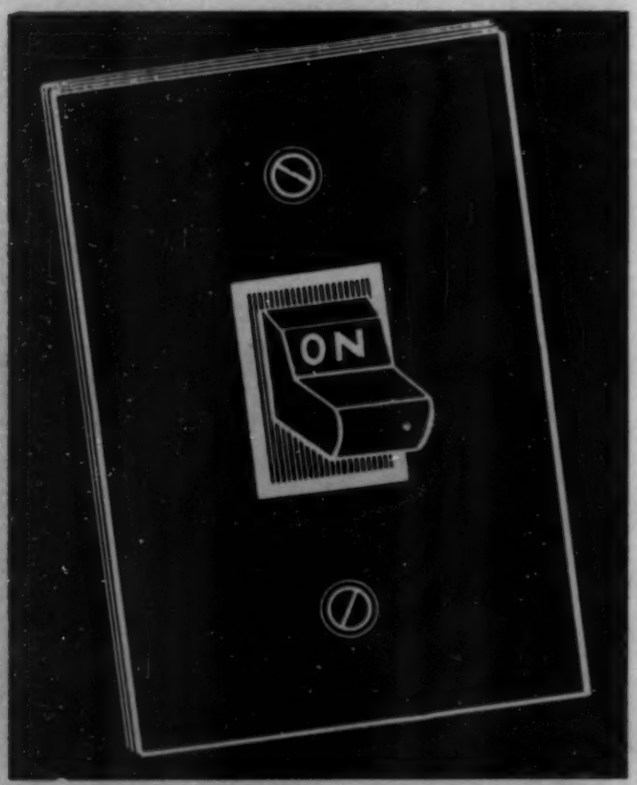
The intensity of this afterglow is rather low compared to electric lights, due to the fact that eyes must become accustomed to seeing in the dark. Everybody has experienced temporary blindness on entering (*Please turn to page 142*)

* Rhode Island Laboratories, Inc., subsidiary of Warwick Chemical Co.



Luminescent plastic lettering for outdoor signs and house numbers should be bold and large for easy deciphering

When the All Clear sounds, householders can quickly locate light switches giving off a phosphorescent afterglow, product of their hours of stored daylight or artificial light



The Army's auxiliary booster tube

WITH the great stress which is now being placed upon bombardment from the air, demolition bombs have become one of the most important production problems for the United States Army Ordnance Department.

Although various types of bombs are now in process of full production, this article will deal mainly with the bomb which has amatol as its prime explosive power. A terrific initial shock is needed when using amatol. In order to get such shock, a much quicker acting explosive must be employed. The explosive now used in most bombs is a tetryl. One of the major difficulties in using tetryl is that it cannot come into contact with the amatol. For this reason, some separator must be used as a detonator. Amatol is a combination of TNT and ammonium nitrate. If a metal booster tube were used, there would be a tendency toward corrosion, due to the action of moisture and ammonium, which would eventually eat through the metal tube and permit the ammonium and the tetryl mutually to ruin each other. After several materials were tried out on an experimental basis, it was finally decided that a standard phenolic woodflour material would be satisfactory. The strength, hardness and heat-resistance of this type of plastic together with its relatively low cost, made it adaptable for this kind of application.

The sectional drawing shown in Fig. 4 gives the general layout of the outer metal casing, the amatol and the separator tube into which the tetryl is placed. This also shows that the detonator acts immediately upon the tetryl, which in turn gives the explosive shock necessary for the demolition action of the amatol.

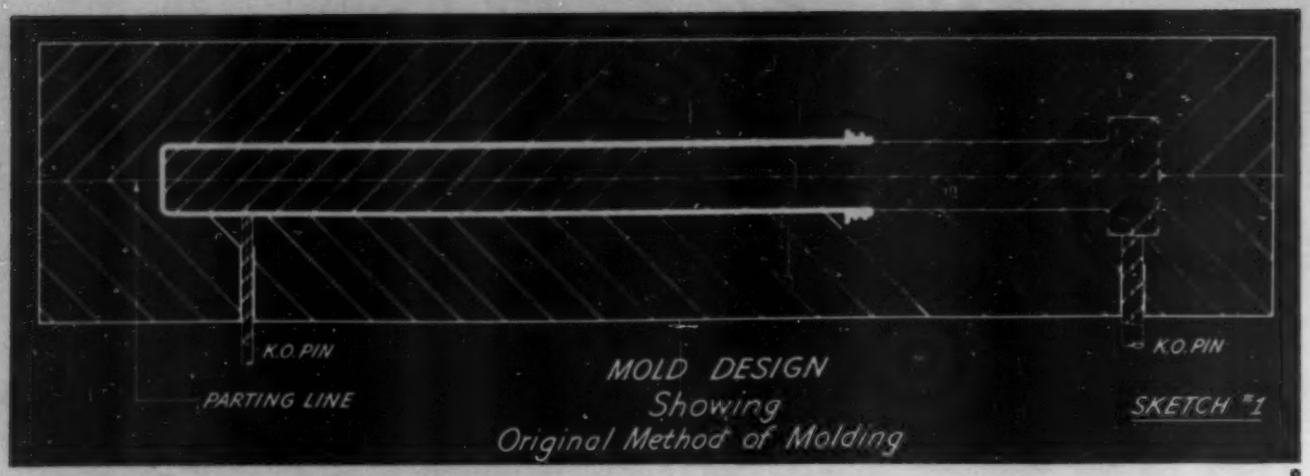
Since this booster tube had to be molded with one end closed, it presented a difficult molding problem because the center plug had no support during the molding operation. Thus it tended to bend, increasing the wall section on one side and decreasing it on the other. One type of mold which was built for the engineering samples, as well as for the first limited production, is shown in Fig. 2. It will be noted that the pressure on the pin was vertical and that a split line ran completely around the molded piece lengthwise. Thus there was the added disadvantage of mold misalignment on the outside of the tube as well as the difficulty of the center plug bending.

However, enough parts were produced from this mold to prove that the tube would perform its function satisfactorily. When it became apparent that the United States would contract to produce munitions for Great Britain, bids for larger quantities of these tubes were sent to various molding companies. One company in the East, not thinking so much of the original contract, but realizing that this part would play a major rôle in Ordnance if the United States went to war, decided to enter a fairly low bid on this job with the full expectation of losing some money before the job was finally licked.

This company, knowing of the difficulties encountered in molding these tubes in the manner shown in Fig. 2, divorced themselves completely from this type of mold and made an attempt to mold the piece vertically. This method is shown in Fig. 3.

Ring or doughnut preforms were made on standard preforming machines. These preforms were loaded by merely dropping them over the force plug. The mold was then closed on low pressure until the top preform came to rest against the portion of the mold which formed the flange. The high pressure was then turned on, and due to the pre-

1—*Booster tubes molded of standard phenolic woodflour composition are strong, heat-resistant, cost relatively little*



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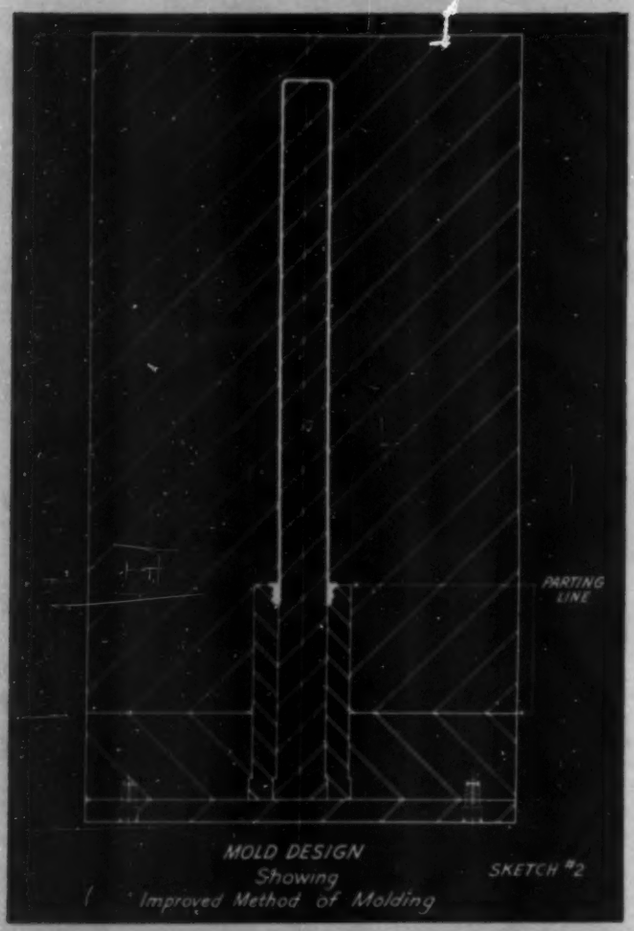

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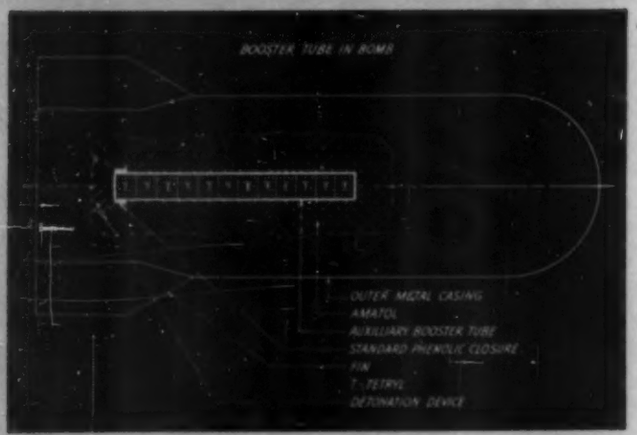

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2—Mold misalignment and center plug bending were difficulties encountered when the booster tube was molded with a split line running lengthwise around it. 3—When a vertical mold was constructed, the material was forced upward in a uniform flow until it closed in at top of mold. 4—Diagram showing position of booster tube in demolition bomb

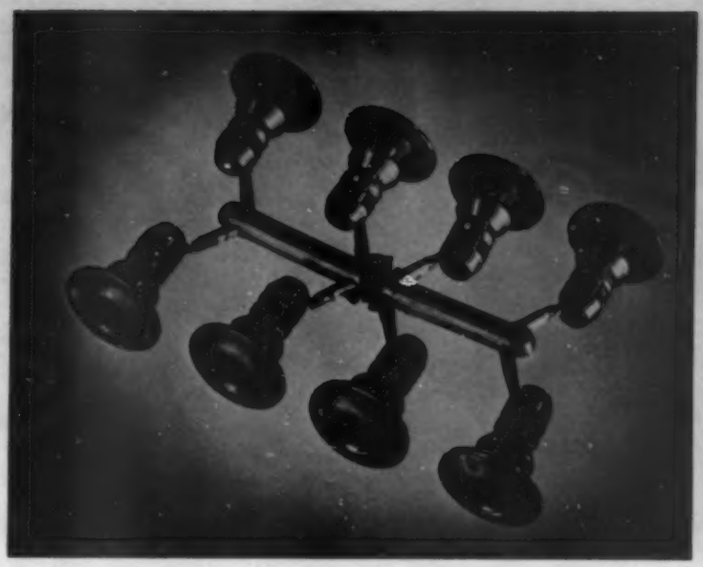
forms being squeezed between the lower portion of the mold and the flange in the cavity, sufficient pressure was exerted to cause the material to flow upward Theoretically, this flow should have been uniform so that as the material flowed up around the force plug the pressure against the force plug was equal in all directions. The material then closed in at the top of the mold. The difficulties which were encountered in controlling the uniform upward flow of this material were numerous. However, after considerable experimentation, the job was finally put into full production and the original contract completed.

The finishing operations on the second method (Fig. 3) of molding were far simpler than in the method first used. The only finishing necessary in method number two was to lathe the flange of the tube and sand the nose end to length. On the contrary, in the mold designed for the first method, the split line running entirely around the piece from one end to the other had to be sanded or filed, and any fin remaining in the thread had to be removed.

As time went on more contracts for larger quantities of the booster tubes were received. More—and better—sets of molds using this same method of molding were produced. Various gages were engineered which gave the molder a very close check on his production at all times. This allowed him to detect any difficulties that might arise before too many rejected parts had been molded.

If the material flows up faster on one side of the plug than it does on the other, it will tend to push the force plug out of true center alignment. The result is a piece with a thin wall on one side, making it below the minimum permissible, and on the other side a wall thicker than the maximum. Very careful control over the phenolic material is necessary to keep this difficulty at a minimum.

However, whenever the force plug gets slightly bent, the inspector in the molding room can load the particular cavity more heavily on the side to which the pin has bent. After several parts have been molded in this manner, with careful check being kept of each piece molded, it will be found that if the pin has not become too badly bent, it will straighten itself out again and normal produc- (*Please turn to page 142*)



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1—Saran parts injection molded eight to the sprue in a single shot. Sprues and runners may be reground and returned to the molding machine. 2—Couplings molded from this material in 2-in. iron pipe size

Saran for injection molding

by R. R. BRADSHAW and R. D. LOWRY*

SARAN is the generic term for a series of thermoplastic resins which chemically are vinylidene chloride polymers and copolymers. These resins are derived from unsymmetrical dichlorethylene made from petroleum and brine as basic raw materials. Ethylene from petroleum and chlorine from brine are combined to form monomeric vinylidene chloride, a clear liquid boiling at 89° F. The monomeric form is polymerized and/or copolymerized to yield a series of resins ranging from flexible, soluble materials with low softening points to hard, tough, practically insoluble ones having softening points of approximately 350° F. The present commercially available injection molding saran is one having a softening point of 240° F. to 280° F. The particular polymer discussed in this article is supplied in the form of pellets for injection molding, in a range of colors, and is designated as Saran B-115.

Outstanding among the properties of this grade of saran are its resistance to most inorganic chemicals and to organic solvents generally. At room temperature it is extremely inert to all common acids and to alkalies with the exception of strong ammonium hydroxide. Most alcohols, esters, ketones and nitroparaffins do not affect it. Certain aromatics such as benzene, xylene and toluene tend to diffuse very slowly through saran but do so with little detrimental effect upon the material. The saran is partially soluble in dioxane and cyclohexanone and is slightly softened by certain chlorinated aromatic hydrocarbons.

It should be pointed out that the resistance of this vinylidene chloride polymer to corrosive liquids and to organic solvents decreases with temperature increases, and that complete test data covering a range of temperatures with many organic materials is not yet available. For this reason it is suggested that the molder or industry wishing to employ saran for injection molding should examine the material in contact with the particular chemicals involved at temperatures covering the complete range over which the parts will be subjected in actual usage.

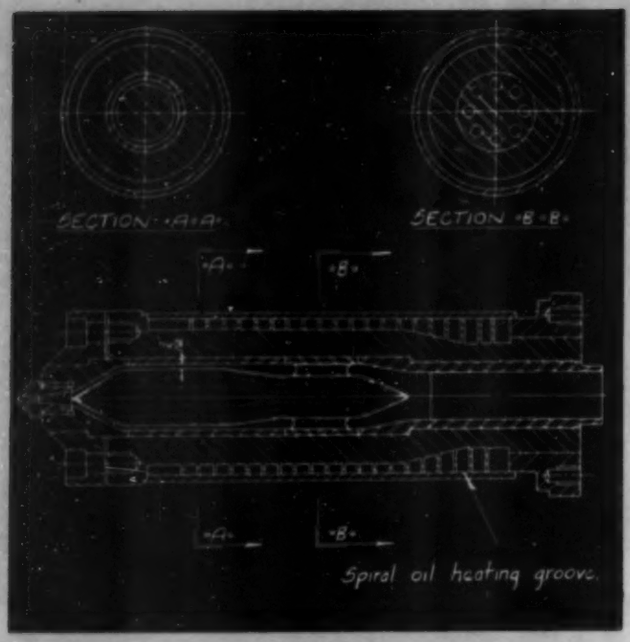
Other characteristics of saran are complete resistance to water on prolonged immersion and its great resistance to moisture vapor transmission. It is nonflammable, dimensionally stable, has excellent mechanical properties, is tough, durable and resists heat warpage and distortion at relatively high temperatures. This last property is a result of the very sharp melting point of the material and its crystalline structure. While quite abrupt, the softening point is sufficiently high to impart to the material an excellent degree of resistance to heat as compared with other thermoplastics. Saran is crystalline in nature and in this respect is different from the majority of thermoplastics. The relationship which this characteristic bears to the molding behavior and the properties of fabricated parts will be discussed later.

The injection molding machine

Saran may be injection molded with commercially available equipment which has been properly modified. The manufacturer of this material, in cooperation with the manufacturers of injection molding machines, has developed designs and specifications for heating cylinders to be used with saran. These designs take into account the special characteristics of the material and consist essentially of a redesign of the cylinder, using certain nonferrous metals.

Because iron present in the metals normally employed in the construction of heating cylinders catalyzes or speeds the heat decomposition of the polymer at temperatures above approximately 260° F., it is essential that all those portions

* Dow Chemical Company.



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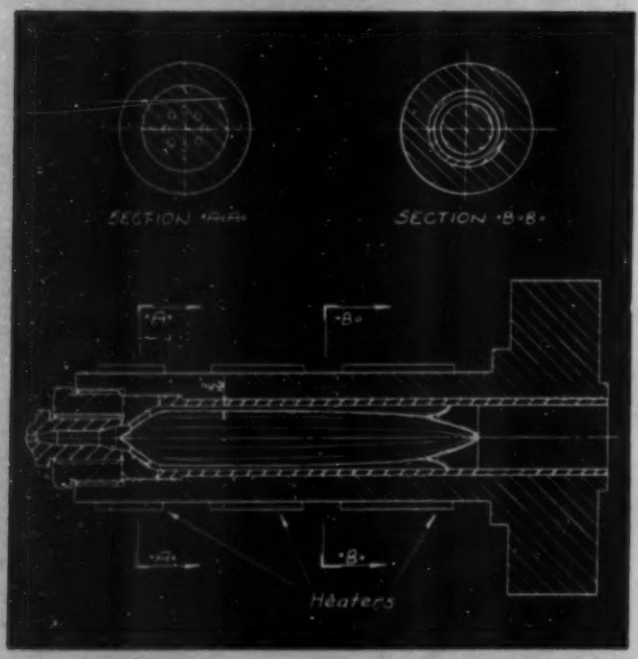

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of the heating cylinder with which the material may come in contact at molding temperatures be of nonferrous metals. These parts are the heating cylinder liners, the torpedo or spreader and the nozzle. Based on present tests, the only metals or alloys recommended for this use with injection-molded saran are Hastelloy "A," Hastelloy "B," Stellite 19, nickel and Z-nickel. It is also recommended that the injection plunger and plunger bushing be chrome- or nickel-plated.

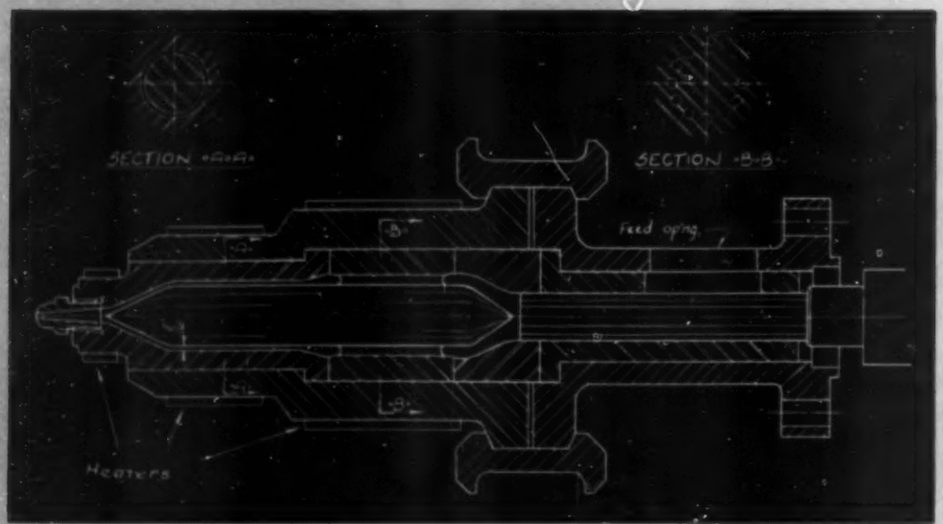
Another feature of the modification is a redesign of the cylinder construction. This is done to effect the maximum in streamlining and to provide the most efficient heating means. The thermal conductivity of the material is low and care must be taken to assure proper and thorough heating. The designs employed make possible rapid and complete heating and provide a speedy, uninterrupted passage of the material through the heated zones. This is accomplished through the reduction of clearances between torpedo and cylinder walls, the elimination of pockets and obstructions where material might be held up, and through zone heating.

Zone heating is recommended because through its use it is possible to heat the material at the most effective point in its passage through the cylinder and without subjecting the portion of it along the cylinder walls to too long a period at unnecessary temperatures. The rear zones are maintained at a lower temperature and the front zones held at somewhat higher heats. This feature is essential to the successful handling of the material.

Figures 3, 4 and 5 show principles of cylinder design employed with three types of commercial injection machines. The outstanding characteristics of each are:

1. Special metal liners, torpedo and nozzle.
2. Reduction of clearance between torpedo and cylinder walls to provide a $^3/_{16}$-in. heating section.
3. Good streamlining.
4. Zone heating.

Another feature of most injection machines which it is recommended be employed in the injection molding of this material is the volume control on the hydraulic system activating the injection plunger. Through the use of this control the speed of injection may be varied. Saran is very free flowing at molding temperature, and so it is possible to inject the material into the mold cavities at excessive speed. When this occurs, a turbulent flow may be developed, and air which normally would be vented is entrapped. The heat generated



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3, 4, 5—Principles of cylinder design employed with 3 types of commercial machine suitable for injection molding of saran. Low thermal conductivity of the material makes essential its rapid and thorough heating, here accomplished by zone heating and reduction of clearance between torpedo and tube

by the compression of the air is sufficient to cause decomposition of the material. This occurs with other thermoplastics also, and with much the same result. Controlling the injection speed by means of the volume control and/or increasing the size of the gates employed will enable the molder to decrease turbulence and eliminate burning. The volume control feature will be found to be most helpful. However, if a machine used with saran is not equipped with this mechanism, much can be done by enlarging and/or streamlining the gates. The single objection to larger gates lies in the trimming necessary at the point of their juncture with the main body of the molding. When possible, gates should be placed on a nonappearance surface of the casting. When this can be done, the objection to the use of large gates may be completely eliminated.

Precautions should be taken to avoid the contamination of molding powders with iron rust at all times. To this end, it is desirable to chrome or cadmium plate the various exposed parts of the feed mechanism and to paint or wax the hopper from time to time.

It should be pointed out that designs other than those shown in the figures are available for use with other types of equipment. It is suggested that in case the molder desires to convert standard equipment, he get in touch with the manufacturer of that equipment.

A heating cylinder which has been adapted for use with the vinylidene chloride polymer may be employed with other thermoplastic materials. The design changes and the special metals employed do not detract from its usefulness with them except in that the reduction of clearance between the cylinder liners and the torpedo does result in a slight decrease in the capacity of the cylinder. In some designs the volume capacity of the cylinder is held to normal through a slight increase in the length of diameter of the unit.

Despite the usefulness of the special cylinder with other materials, it is recommended that both a standard and the special cylinder be obtained. This suggestion is based on the fact that it will be found difficult to purge a cylinder filled with other thermoplastics by the expedient of running saran behind it and vice versa. This is due to the indicated operating temperatures employed with various materials. In the case of saran, the indicated temperatures are in the range of 300° F. to 350° F., while with most other thermoplastic materials the indicated temperature varies from 350° F. to 500° F.

The injection mold

Despite the fact that special metals are required for the hot zone portions of the injection machine, ordinary steel dies may be employed in the injection mold for use with saran. The use of the usual grade of steel is recommended.

Dies may be constructed in conformity with standard designs and practice. Because of the sharp softening point of the material and its low viscosity and free-flowing characteristics at molding temperatures, all lands should be carefully ground and lapped to fit, and clearances around ejector pins, etc., should be reduced to a working minimum in order to eliminate excessive flash.

Gates may be standard, but because of the free-flowing

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6—Here the vinylidene chloride material has been injection molded over a copper insert. 7, 8, 9—Gasket holders, spinerette coupling and cover plate—a group of diversified moldings which show the industrial possibilities of injection molding with saran. Their resistance to organic solvents and to inorganic chemicals is an outstanding property

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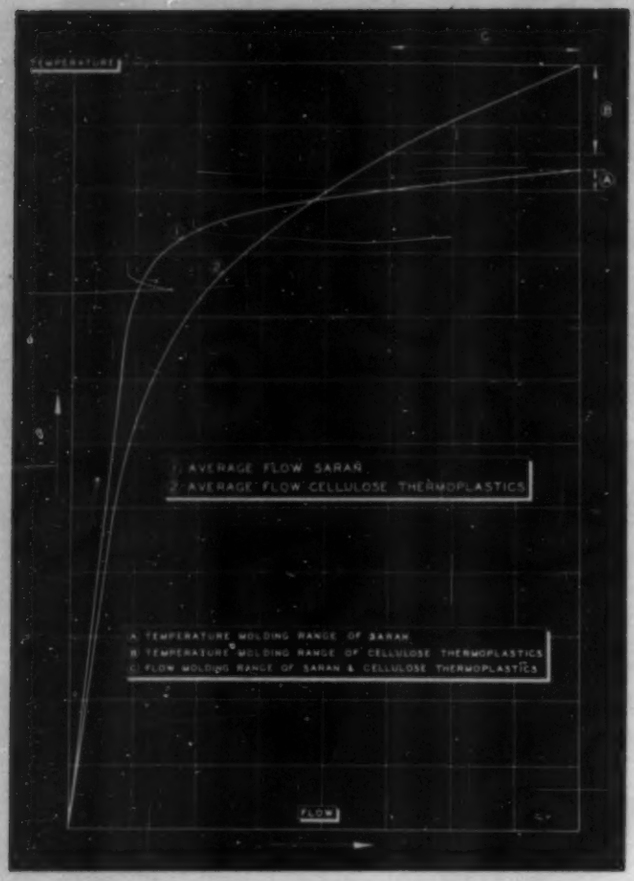

TEMPERATURE
1 AVERAGE FLOW SARAN
2 AVERAGE FLOW CELLULOSE THERMOPLASTICS
A TEMPERATURE MOLDING RANGE OF SARAN
B TEMPERATURE MOLDING RANGE OF CELLULOSE THERMOPLASTICS
C FLOW MOLDING RANGE OF SARAN & CELLULOSE THERMOPLASTICS
FLOW

10—*Comparative curves show the material's ability to resist flow at higher temperatures than do most thermoplastics*

characteristics of the material, they may be smaller than normal in special cases. It is recommended that as large a gate as is practical be employed wherever possible. The use of very small gates is not recommended unless the design of the piece required placement of the gate on an appearance surface.

Mold shrinkage allowances should be on the order of .008 in. per inch for maximum efficiency. The mold shrinkage of the material varies, but can be quite closely controlled through careful adjustment of molding conditions. At maximum molding speed an .008 in. per inch shrinkage may be expected, but with saran, as with other thermoplastics, the shrinkage value will be determined also by the thickness and contour of the section.

Dies for use with the vinylidene chloride polymer should be provided with means for maintaining a controlled temperature over a range of from 70° F. up to 212° F. This may be accomplished through coring for hot water or steam or through the use of cartridge or strip type electrical heating units. Most injection molds already constructed with cooling cores will be found to be completely satisfactory for use with this new thermoplastic in this respect as well as in their design and construction.

The molding cycle and molding conditions

The temperatures, injection speed and pressures required in the injection molding of this type of saran are well within the range of standard injection equipment. Indicated temperatures fall within the range of 300° F. to 350° F. and pressures employed in molding are in the range of 10,000 lb. to 30,000 lb. per square inch.

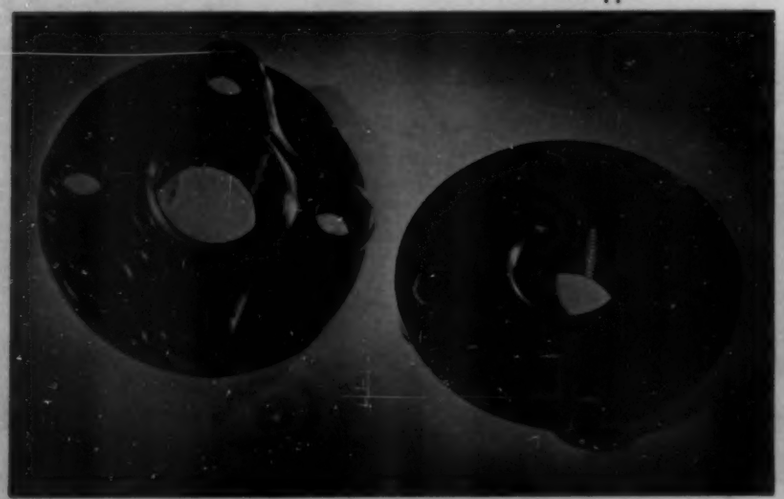
Because of its sharp melting point, parts made of the material can be molded only over a very narrow temperature range, regardless of the cross section and weight of the object. Overheating results in destructive breaking down of the material, just as overheating "burns" other plastics. In many cases, it is unnecessary to alter the heat conditions when changing from one mold to another.

The materials for injection molding are supplied in the form of free-flowing pellets which assure an even feed in the hopper and which are free from dust and fines. Because it does not absorb moisture from the atmosphere, it is not necessary to dry the material prior to its use in the injection machine.

It is advisable that the injection dies employed be heated rather than cooled, and it is recommended that a temperature of 160° F. to 200° F. be maintained depending upon the cross section of the piece. The material is crystalline in nature. When completely melted it becomes noncrystalline or amorphous. If the fused plastic is chilled rapidly the amorphous state may be temporarily maintained. In this condition the material is soft, flexible and of comparatively low strength. Recrystallization of the material must be effected not only in order to realize its maximum properties, but also to make possible the ejection of the piece without distortion. Since recrystallization is a function of temperature, the die tem-

11, 12—*A flange to fit a 2-in. iron pipe and two hose adapters injection molded of saran*

11



12

TABLE I.—CHEMICAL RESISTANCE OF SARAN AT ROOM TEMPERATURE

(Three months of continuous exposure)

Reagent	*Stability rating*
60% H_2SO_4	Excellent
10% H_2SO_4	Excellent
35% (Conc.) HCl	Excellent
30% H_2SO_4	Excellent
10% HCl	Excellent
65% (Conc.) HNO_3	Excellent
10% HNO_3	Excellent
Glacial acetic	Excellent
10% Acetic	Excellent
5% H_2SO_3	Excellent
Conc. oleic	Excellent
Ethyl alcohol	Excellent
Ethyl gasoline	Excellent
Turpentine	Excellent
Triethanolamine	Excellent
Lubricating oil	Excellent
Linseed oil	Excellent
Bleaching solution	Excellent
10% Duponol	Excellent
10% Zinc hydrosulfite	Excellent
15% $CaCl_2$	Excellent
Water	Excellent
Air	Excellent
98% (Conc.) H_2SO_4	Good
10% NaOH	Good
Carbon tetrachloride	Good
15% $FeSO_4$	Good
50% NaOH	Fair
Ethyl acetate	Fair
Acetone	Fair
Methyl iso-butyl ketone	Fair
Benzene	Fair
10% NH_3	Poor
Ethylene dichloride	Poor
Diethyl ether	Poor
O-Dichlor benzene	Poor
28% NH_3	Unsuitable
Dioxane	Unsuitable
Bromine water	Unsuitable
Chlorine water	Unsuitable

The stability rating given is based upon observed changes in color, weight, dimension, tensile strength and hardness of the samples tested.

perature is extremely important. Amorphous saran may be retained in that condition indefinitely at sub-freezing temperatures, but tends to recrystallize at an increasing rate with temperature increases up to 212° F. At 175° F. recrystallization is very rapid and will become substantially complete within a few seconds.

If the material is injected into chilled dies while in the hot amorphous state, recrystallization will be retarded. In such an instance the pieces will behave in a manner similar to a cellulose derivative casting which has been insufficiently cooled or "set" prior to ejection.

Through the use of hot dies recrystallization may be accomplished almost instantaneously and molded parts may be ejected without damage by the knockout mechanism at rapid cycles. Because of the residual heat retained by heavy sections, recrystallization is very rapid and enables the molder to obtain much improved cycles in this type of section. Moldings with a one-inch cross section and which required cycles of up to 7 minutes with other thermoplastics have been

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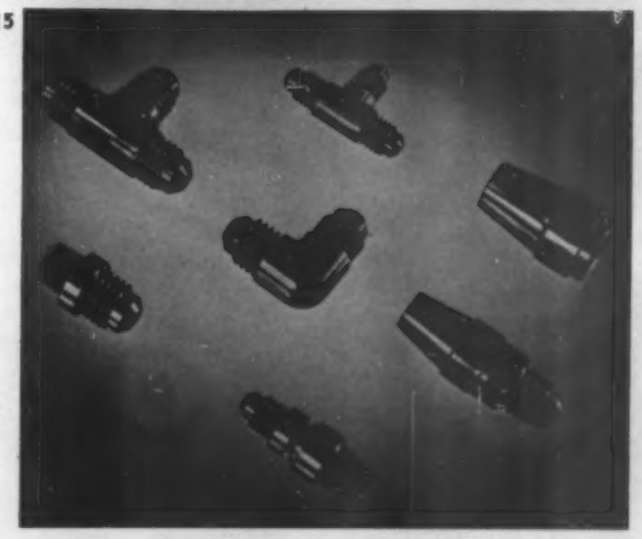


13, 14—*Top and bottom views of masking parts, showing molding around inserts.* **15**—*Group of injection molded threaded fittings of varying shapes. All are of saran*

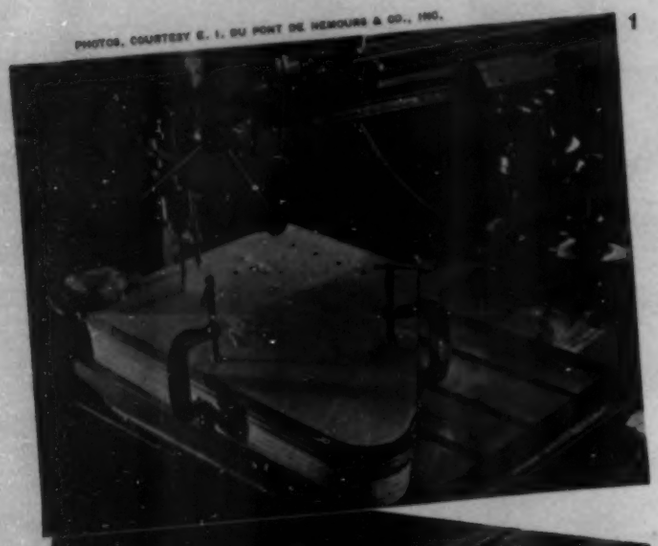
successfully molded at 1-minute cycles with this material. Cycles possible in molding thinner sections will compare most favorably with those obtained with other thermoplastic materials.

Sprues, runners, reject parts and the like may be reground and returned to the injection molding machine as with other thermoplastic materials. Great (*Please turn to page 118*)

Machining acrylic plastics

by W. J. ANTENER*

PHOTOS, COURTESY E. I. DU PONT DE NEMOURS & CO., INC.



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IN common with many plastics, the acrylic type is quite freely machined. Cutting is more or less comparable to that used for hard wood except that the plastic, unlike wood, has no grain and is not easily split. Tools similar to those used in woodworking can be employed, some of them being identical. However, where the quantity of parts to be machined is large, it is advisable to employ alloy (*high-speed*) rather than carbon steel, as such tools hold their edge longer. Many tools employed for metal working can also be used although certain differences in grinding are recommended in some instances and higher cutting speeds are usually advocated Acrylic plastics machine more freely than the freest cutting brass, which is among the easiest metals to machine.

Under these circumstances, it is not surprising to find relatively light and fairly high speed machines most commonly chosen for machining acrylic plastics. Some such machines are identical with those employed in woodworking and others are duplicates of metal working machines. Since cutting is free and rapid, the moderate power applied in light machines is ample for plastics of the acrylic type. A great advantage of the light machine tool is that its application by industry is extremely wide. Since the number of such tools needed is great, they are suited for production in large quantities. Because quantity production methods are applied in their manufacture, the cost per unit is moderate. In fact unit costs are much lower than for heavy tools which have to be sold at a much higher price per unit, since they are needed—and built—in smaller quantities. This is more or less equivalent to saying that, for the machining of almost all plastic materials, the

* Walker-Turner Co., Inc.

***1**—Polished acrylic sheets may be stack drilled without scratching by a radial type of drill press.* ***2**—Regular woodworking machine used for joining the sheets gives them square, mitred or beveled edges.* ***3**—A shaper, using a template which bears against a depth collar, needs no coolant for doing contour work.* ***4**—Acrylics are readily machined with hand tools in a woodworking lathe like this one*

investment required in machine tools is decidedly moderate.

Drilling of acrylic plastics is so rapidly and easily done on light drill presses that it is rarely necessary to use geared or multiple-spindle heads. Most work is done with spindles carrying only one drill, but when several holes of different sizes are required in the same piece, the latter is often passed through several single-spindle drill presses or presses having a common bed, and several identical spindles are employed.

Extensive tests have shown that a peripheral speed of 120 ft. per min. is ideal for drilling acrylic plastics, provided that a flood of coolant (which is recommended) is applied. This serves as an index to the preferred speed of the drill (from which the spindle speed is readily computed), although it is not necessary to adhere closely to this speed. Drilling, except for deep holes, is often done dry, but a mild soap solution used as a coolant is advocated in order to form a smoother hole, and also help to keep the tool and work cool. Feeding is commonly by hand but can be done automatically. It is recommended that the rate of feed be decreased as the depth of hole increases and that the drill be withdrawn at least once for each half inch of depth to help clear the hole of chips.

Although standard drills can be employed, better results are attained by using a drill ground with a flatter lip angle (70 deg.) than the standard 59 deg. angle lip. It is highly desirable to have the lands at the edge of flutes highly polished, as this tends to reduce friction and consequently, the heat generated. For through holes, the piece should be backed up with wood, soft metal, or scrap plastic to prevent the piece from being chipped around the hole when the drill breaks through. Large holes are readily cut with a hollow end mill (trepanning tool) or with a fly cutter. The spindle of the press should be free from side or end play, as these may result in the drill grabbing. In general, it is best to clamp the work, although holding by hand is often satisfactory, especially for holes in thin sheet or plate.

The common type of fixed spindle drill press is most generally used on plastics. However, where there are several holes to be drilled which are widely spaced over a sheet of considerable size, a light radial drill (Fig. 1), which is quickly and easily shifted from hole to hole has definite advantages. With this type of drill the work can be fixed (if desired) and all holes drilled without shifting it, or several sheets can be arranged for stack drilling, as illustrated. This is of special advantage on transparent polished sheet which, unless protected by paper covering, is likely to be scratched by frequent sliding along bed of the press. A radial drill is essential for sheets having holes too far from the edge to be drilled on a press which has its head fixed in reference to the column.

Tapping of acrylic plastics can be done readily in a drill press, but the speed of the tap recommended is about 25 percent slower than for soft brass. Fairly coarse threads are better than fine ones and plenty of coolant is recommended, if not essential, for large holes, although dry tapping of holes $^{3}/_{16}$ in. or less in diameter can be done.

Joining or planing of acrylics is similar to operations required for wood and employs the same machinery. As the faces of the plastic sheets are always smooth, planing, which is essential for lumber, is rarely required for plastics. Joining is the same operation as planing but is done on the edge of the piece, to give it a truly square, beveled or a mitred edge, whichever may be desired. The cutter—the same as that used for wood—is commonly about $3^{1}/_{2}$ in. in diameter and turns at 3500 to 4000 r.p.m. In this machine, the work is fed by hand and is guided parallel to the cut and across the horizontal cutter by a guide set at the desired angle (Fig. 2).

Shaping is more or less similar to joining except that the spindle and axis of the cutter are vertical and the edge is commonly given a curved or stepped contour rather than a flat surface or a mitre. The work can be done on a long strip, with or without a guide, or may follow around the contour of a piece, as shown in Fig. 3. In the latter case, the work can be guided entirely by hand or, if properly set up with a template bearing on a depth collar on the spindle beside the tool, the work can be guided by the template as it is kept in contact with the collar. This operation is the same as that done in woodworking and the same machine and cutter are employed. The latter is usually about $2^{1}/_{2}$ in. in diameter and turns at 5000 to 8000 r.p.m. No coolant is needed in cutting acrylic plastics on jointers, routers or shapers.

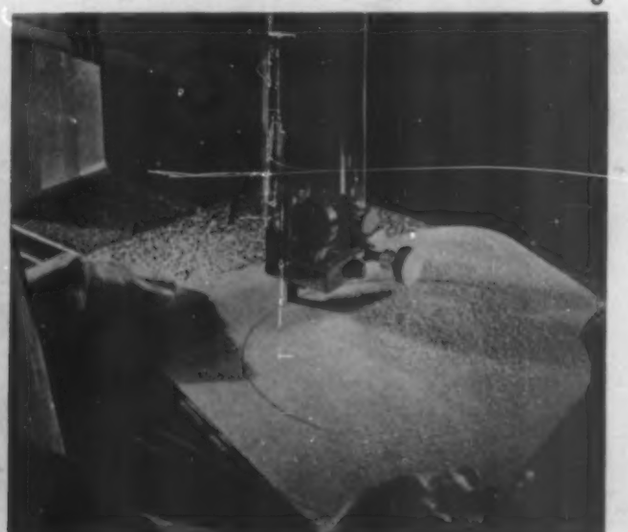
Turning of acrylic rods is readily done on standard woodworking lathes, using hand tools. A surface speed of about 150–200 ft. per min. is recommended and ordinary woodworking tools can be employed although tools of high speed steel hold their edge longer. For precision work, where close dimensions must be held, a metal screw-cutting or engine

(*Please turn to page 76*)

***5**—Circular saws produce narrow slots and are suitable for straight-through cutting. Fewer teeth make faster work.* ***6**—Eye and hand guide a band saw as it cuts a circle of acrylic from sheet stock*

5

6



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Plaskon was picked for service in these instruments because of its superior *electrical* characteristics. The most unusual electrical property of Plaskon, and the one of primary importance to electrical engineers, is its complete freedom from tracking under high electrical stress. Plaskon is especially suited for use with high voltages and high frequencies, and for insulators continually subjected to voltage flash-over. Plaskon is shock-resistant and non-shatterable; its dimensional stability is good; its electrical properties remain constant; and it has an exceptionally low degree of heat-transference. Plaskon has excellent tensile and flexural strength for strong assemblies.

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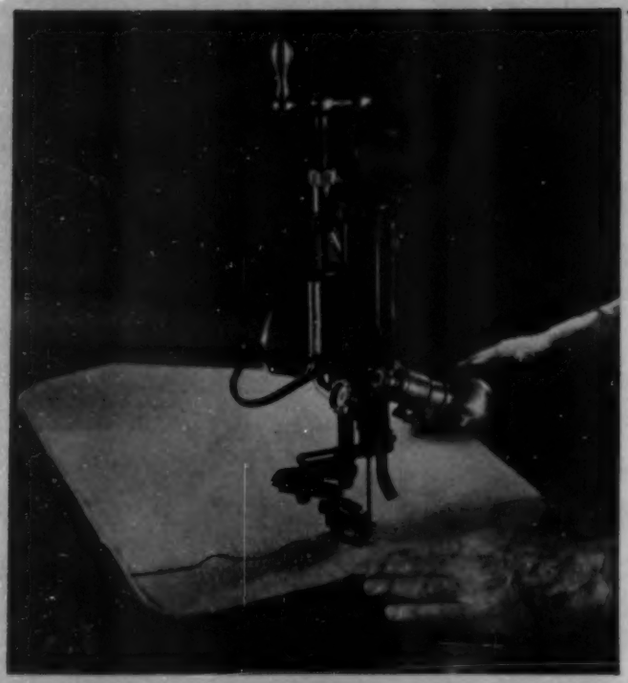

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7—Intricate work on acrylics is best done by a jig saw, which is the only type suitable for cutting holes in these sheets. 8—Abrasive disk grinder sands the edge of the sheet. The table can be set to give a square or beveled edge

lathe is used, but then, too, high speeds (as above) and light cuts are advocated. The work can be chucked or held on centers, although chuck jaws will mark a polished surface unless it is protected. Turning tools are commonly shaped and sharpened much as those used for cutting brass. Small parts can be produced rapidly from bar or tubular stock in a screw machine (which is really a special form of lathe).

Sawing, a common operation on acrylic plastics, is performed dry. Several types of saws such as are used for cutting both wood and metal are applicable. Band saws (Fig. 6) can be employed for either straight or curved cuts and are rapid in operation. Band saws commonly run, when used on acrylic plastics, at 1500 to 2500 ft. per min. tooth speed. The thinner the material cut, the finer the teeth required. Since coarse teeth tend to chip the plastic more than fine teeth, it must be decided how much chipping is permissible for each particular cutting job, in order to take advantage of the more rapid cutting speed of coarse teeth. On sheets $^1/_4$ in. thick, a blade $^3/_8$–$^1/_2$ in. wide which has 18–22 teeth per in. gives good all-around results, and permits a fairly rapid cutting rate. The narrower the blade, the smaller the radius which it will saw. Blades must be given enough set to clear the cut, but excessive set tends to result in chipping. A sharp cutting edge should be maintained as is necessary for all efficient work and all tools.

Circular saws are well suited for through straight cuts and for producing narrow slots (Fig. 5). A 10-in. saw turning at about 3500 r.p.m. and having from 6 to 10 teeth per in. does good work if kept sharp. Saws should be hollow ground, in which case no set is required, but if they are not hollow ground, just enough set for the saw to clear is needed. A coarse set tends to produce a rough cut and a kerf of excessive width. If a mitre gage is used in sawing, it should support the work close to the blade. The optimum number of teeth depends upon the thickness of stock, but, for the most rapid sawing, the fewest number of teeth per inch which yields a cut of adequate smoothness and freedom from chipping, should be used when working with acrylics.

Jig saws are useful chiefly for cutting holes and for making intricate cuts (Fig. 7), or those of such small radii that a saw as wide as a band saw is not feasible. A narrow blade is needed for intricate sawing. The saw should have enough teeth per inch so that not fewer than three teeth are in contact at all times with the edge of the sheet. Fine teeth make for smooth cutting but have more tendency to gum than coarse ones which cut more rapidly. Stock over $^1/_2$ in. thick should be cut with a band saw rather than with a jig saw. A saw having a $^1/_2$-in. stroke commonly runs at 1140 to 1740 strokes a minute. It is best not to use blades of minimum width except when intricate work has to be done. Jig saws should be given just enough set to clear the work properly.

Sanding, especially of the edges of sheets, is effectively performed either on a disk grinder or on a belt sander. Silicon carbide abrasive cloth is advocated, the grit size being 60 to 80 for roughing cuts and as fine as 300 for finishing cuts. A surface speed of 5000 to 7000 ft. a minute usually yields best results. The work can be performed either wet or dry.

Buffing generally follows sanding and must do so if a polished surface is required. This operation can be done on any buffing machine, though one with a horizontal shaft is commonly used. Some work is facilitated, however, by the use of the flexible shaft type of equipment. Standard buffing wheels are used. The buffing agent is usually rouge, soda ash or zinc oxide, and these are usually applied wet. When a final luster is required, waxing is done, the wax being applied to a dry buff in stick form. Buffing wheels of 6 in. diameter should turn at about 800 to 1000 r.p.m.

Cut-off work can be done with circular or band saws, but smoother cuts are attained and cutting is more rapid when done with an abrasive cut-off disk. The type of wheel recommended is one of 12 in. diameter and about $^1/_8$ in. thick and it should turn at about 3600 r.p.m. When the wheel is arranged so that it can be traversed across the work, sheets can be cut readily and the cut is much smoother than that made by a saw. Abrasive cut-off disks can be used wet or dry, *though wet cutting is advocated*, as the work remains cooler and there is less tendency for the wheel to load.

Although a few other types of machines are used occasionally, those named above have attained widest application. Nearly all are commonly found in (*Please turn to page 134*)

The most valuable plant we have...

never earns a cent!

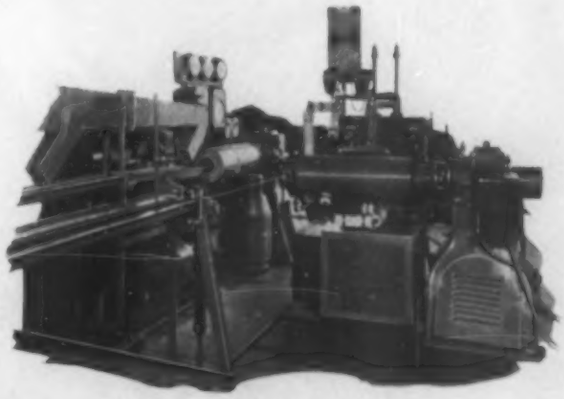
Out in a corner of our factory yard at Akron stands an inconspicuous little building that houses one of our most active operations. It loses money every month, regularly; yet we consider it the most valuable plant we have.

This is our Pilot Plastics Plant, where all new developments are put through the acid test of actual operation. This is where ideas come to the crossroads, one path leading to discard, the other to further development, refinement and adoption. This is where National plastics extruders are rigorously tested and proven before going out to earn their living, and make it possible for many men and women to earn theirs.

What that Pilot Plant accomplishes for our customers cannot be measured in money. From it we obtain facts and figures otherwise unobtainable. Facts about raw materials and processes—the merits and deficiencies of each.

It was here we proved there can be no "jack-of-all-trades" in plastics extruding machines — that each plastic material has certain characteristics which can be successfully handled only if the extruder is built for that specific job.

Because of this fact-finding Pilot Plant, the war work we're doing for our country, the plastics extruders we're building for essential uses; and the time-saving, cost-cutting production machinery we will again build for the rubber industry when peace returns, all can be depended upon to do their jobs better than they've ever been done before.

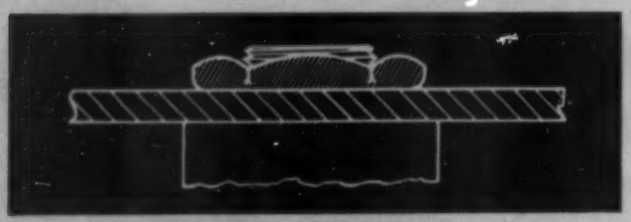


Plastics Division

NATIONAL RUBBER MACHINERY COMPANY

General Offices: Akron, Ohio

One-piece assembly device



1

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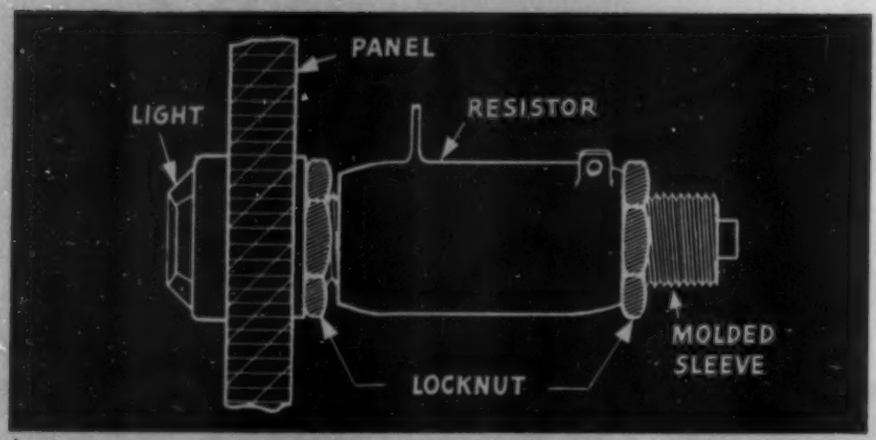
THE plastics industry has been given a new self-locking device for light assemblies. This is a one-piece job, and is a single-thread lock nut, pressed from sheet steel and hardened and drawn to spring temper after forming.

The fundamental design is incorporated in a number of types of nut, each having its own special advantages. The locking part of this device is essentially a cone with a hole in the center, having its inner edges formed to the true pitch of the screw. This inner edge is slotted at intervals to form spring jaws, or teeth, which close in and grip the screw thread when the assembly is tightened. This locking action is shown in Fig. 5 on page 128.

There have been specialized applications for this lock nut. One of these is a plastic switchboard-panel indicating light, assembled in schematic drawing (Fig. 3), and disassembled in Fig. 4. The sleeve is molded with a continuous thread and the socket takes the form of a reflector which has been painted to give it the proper reflecting quality. The continuous thread construction coupled with lock nuts and resistor unit makes a positive locked assembly on panel boards, varying from $^1/_{13}$ in. to 2 in. in thickness.

A tubular capacitor, formerly made of aluminum, has been made available for chassis mounting through the use of a molded phenolic container and a one-piece lock nut. It is claimed that this assembly is jar and vibration proof, and that there is effective insulation from chassis to container, providing ample factor of safety for voltage surges.

These specialized jobs were the (*Please turn to page 128*)



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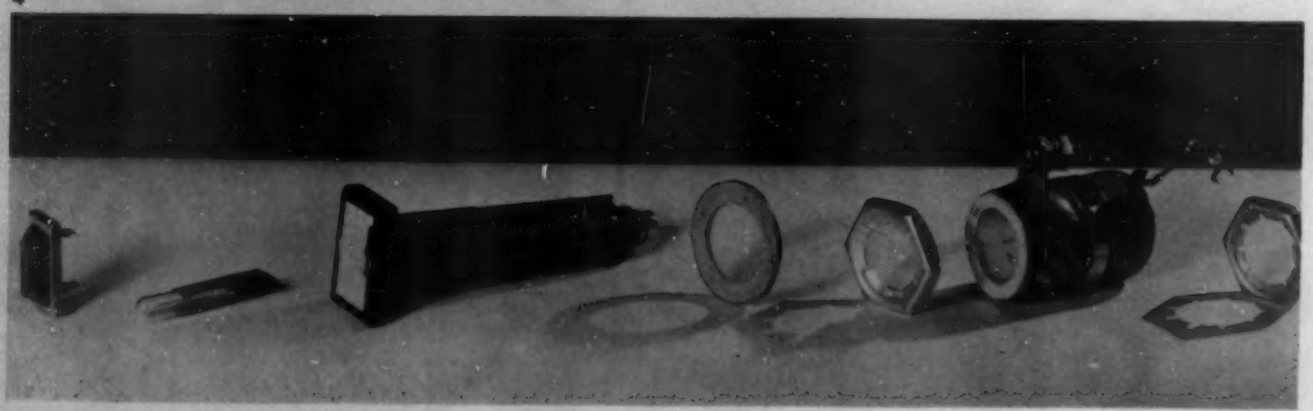

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1—Schematic diagram showing method of assembling tubular capacitor to chassis by use of one-piece assembly device. 2—Tubular capacitor in plastic container with molded thread and fastening device which permits chassis top mounting. 3—Schematic drawing shows component parts and method of panel assembly of plastic flush mounting indicating lamps. 4—Parts of indicating lamp, showing molded sleeve with continuous thread and two fastening devices

Heating by short wave

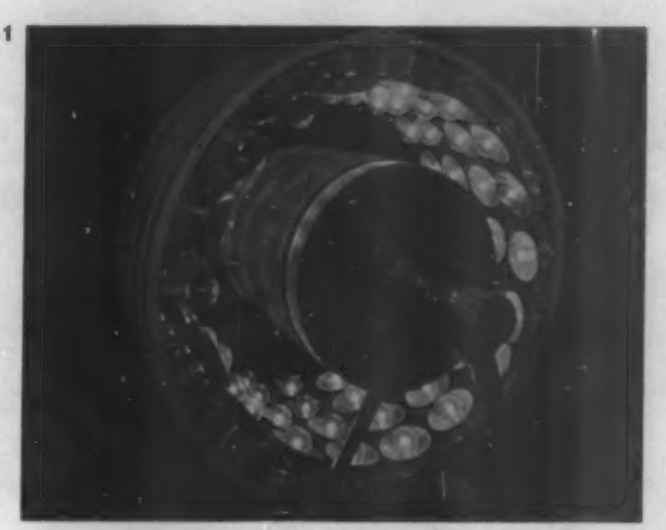
ONE of the most bothersome problems in finishing plastics products has been development of uniform heating arrangements for drying finishes, moisture drying and softening of plastic materials.

Production engineers at the Ford Motor Company have solved this difficulty through the use of heat produced by infrared lamps, which utilize the radiant energy in the short wave lengths in the infrared range of the spectrum. Company experts claim it is much superior to other methods.

A striking instance of the advantage of the use of infrared heat over the old steam type oven formerly used in company plants is shown in the heat treatment of all molding materials. The steam type oven took considerably more time to perform operations, a factor which affected the plasticizer, and was otherwise less efficient. The change-over to the use of infrared resulted in an immediate time saving when all molding materials were so heated before going into the machine hoppers. In addition—and highly important—a more uniform product was produced, with a resultant cutting down in scrap. Further advantages of the infrared treatment of plastic material are lower over-all costs, and the efficiency which results from the more flexible type of equipment used.

Flexibility of infrared heating used in a variety of treatments to facilitate the production of plastic parts is obtained by cutting banks of light in and out as required by the number of parts on the conveyor line. Lights are adjustable in any direction. In many installations, the distance of the lamps from the parts or material is adjustable for the full, effective range of the lamps—that is, from six to eighteen inches. Infrared drying also lends itself to portability, as small banks of reflectors can be mounted on rollers and used for spot drying of finishes both in automotive and in aircraft manufacture.

1



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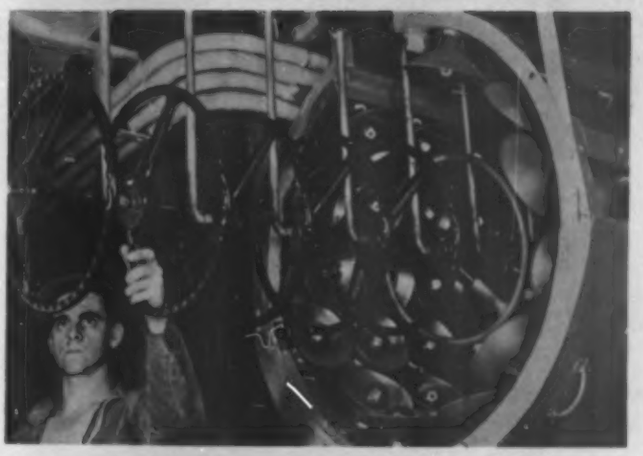

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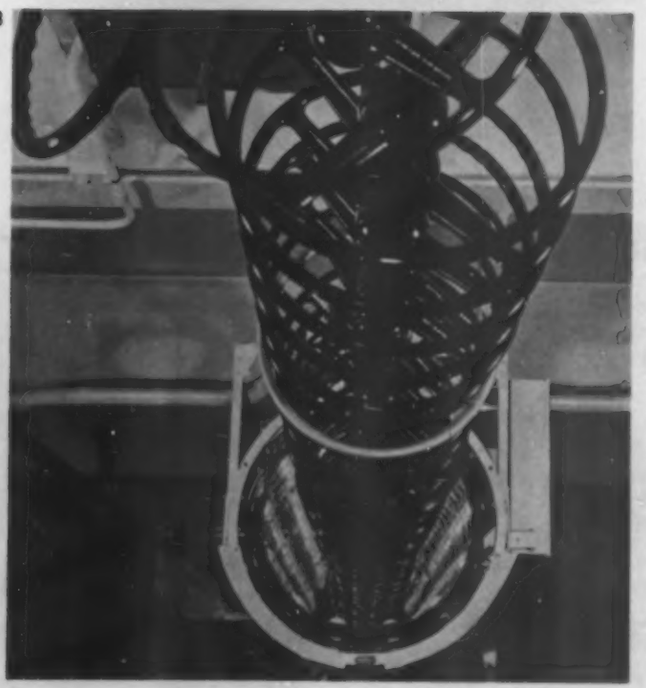
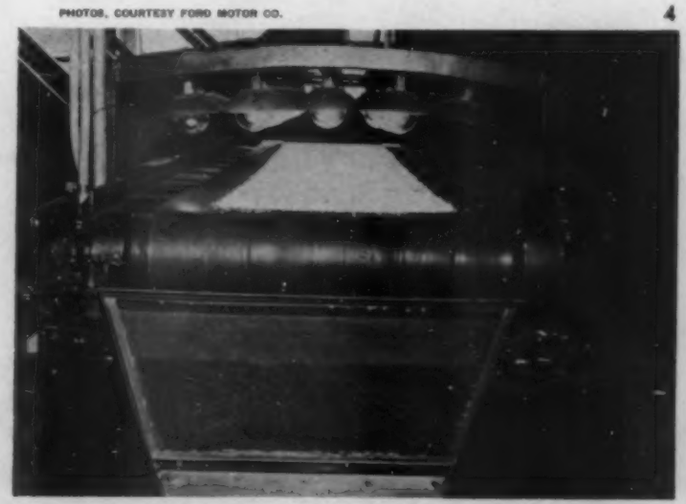


1—Infrared lamps provide radiant energy for speedy production of plastic materials. Phenolic resin-impregnated armature undergoes drying operation in a special bank of infrared lamps. 2, 3—Two views of molded steering wheels about to enter cylindrical bank of infrared lamps. 4—Molding material passes under lamps on this new time-saving machine, which replaces the steam oven

PHOTOS, COURTESY FORD MOTOR CO.

4



Reprints of all stock mold pages which have been published to date, with a complete index of suppliers, are available to Stock Mold Service subscribers

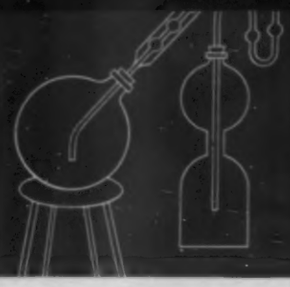
Stock molds

SHEET ONE HUNDRED TWENTY-FOUR

1461–1462. Representative samples of standard shapes, and shapes which can be made to order are illustrated here. They are hard or resilient as desired, light in weight, shatterproof and rustproof, and may be had in opaque or transparent materials, attractive colors, and are labeled in the manufacturing process. Formed in vial, jar, bottle and tube shapes, the containers can be utilized for medical purposes such as applicators used in the feminine hygiene field; for packaging capsules, pills, ointments and other remedies. Can also be used for packaging lipstick refills, various tools and machine parts, drills and fine instrument parts, toothbrushes, styptic pencils and dental floss, novelties, etc. Closures are made of same materials and can be slipped on, or vial can be threaded for metal screw cap. Metal slip-on caps when available can also be furnished for unthreaded vials. Containers are made in diameters from 3/8 in. up to 1 3/4 in.; lengths can be varied any fraction of an inch up to 6 in. on most of the sizes.

Note: Restrictions on supplies of raw materials, etc., may possibly limit current production of some of these stock items. Please check with molders as to quantities available

All molders and extruders are invited to submit samples from stock to appear on this page as space permits



Impact strength of plastic sheet

by C. S. MYERS*

THE theory of impact testing and various types of impact tests are reviewed to show that the standard excess-swing pendulum does not give a true or absolute value of the impact strength of plastics. An impact test for plastic sheets is described which duplicates the type of stresses imposed in service and is capable of testing sheets of various thicknesses normally used in service. The results of the method of impact testing described are given for a series of rigid sheet compounds of copolymer vinyl chloride-acetate resin. The effect of temperature on impact resistance, measured by the method described, is given for two vinyl copolymer sheet compounds to show the expected drop in impact resistance corresponding to a decrease in temperature. Comparative results are given for a number of various types of plastic sheet to show that impact resistance is a specific characteristic not directly related to the other physical properties of the material.

Definition of impact strength

The theory of impact testing and the behavior of materials under dynamically applied loads have been previously considered by Houwink[1] and Kauzmann.[2] The theoretical considerations of impact testing of solids may be resolved in practical terms and briefly summarized as follows: Under increasing rate of application of stress, i.e., under suddenly applied or impact loads, the resistance of a solid material to stretching (plastic deformation) increases until the resistance to flow exceeds the cohesion forces of the material. Above this critical rate of load application there is a sudden drop in the energy required to break the material and it breaks with a brittle fracture. The fracture, once initiated, propagates itself with comparatively little need of continued application of load. The appearance of the fracture is characteristic of impact failure and is significantly different from the tough, fibrous fracture produced by slow tearing under static loadings or low rates of shear.

Service failures of materials often occur with little deformation. Therefore, they are sudden and often disastrous. The causes and effects of failure under impact have naturally attracted the attention of engineers from comparatively early times. However, the development of special machines designed to subject materials to impact forces as a means of investigating brittleness began only about 1900.[3] Since then the engineering literature on impact has become of increasing importance, and a considerable variety of testing machines and methods have become established in practice.

Any discussion of the property of impact resistance, especially in the field of plastics, must by necessity draw on the experience of those studying a like property in metals. As plastics engineers have borrowed the standard physical tests on metals, it is natural that they draw on the experience of the metallurgist in the study of impact strength. Although voluminous, the literature on impact testing of metals is also controversial. The following review[4] of the various testing methods for the study of impact strength shows the widely divergent means of approach to the measurement of toughness in tangible terms. The summary of the various tests for impact resistance is given for the purpose of correlating their principles of operation.

Summary of various test methods

1—*Proof tests* are those in which a specimen or finished piece is subjected to a specified blow which it must withstand without failure or with a specified maximum damage.

2—*Increment-drop tests* are those in which a weight (usually known as the tup) is dropped upon a specimen from a height which is increased in steps until failure occurs. The utility of the increment-drop test has been reported by Burns and Werring[5] in the testing of molded telephone handsets. The results reported show the lack of relation between the results of any single impact test on standard test specimens of four phenolic materials and results of tests on the completed apparatus fabricated from the same materials. The choice of the increment-drop guillotine tester over conventional pendulum impact testing methods has been shown by Callendar.[6] The conclusion was advanced by Callendar that the most commonly used excess-swing pendulum method of impact test is totally unsuitable for plastics owing to the very large factors of shearing, tearing friction and the "broken-half" error inherent in this method of testing. The complication of errors tends to obscure and confuse the results as an indication of brittleness. An increment-drop test was advocated and described by Callendar, showing the significant differences in the strength properties of hard rubber and phenol-formaldehyde resin in the filled and unfilled varieties.

3—*Single-blow drop tests* are also made by special machines which drop a tup of sufficient weight to break the specimen with a single blow. In these machines various means are provided to determine the excess energy remaining in the tup after fracture so that the energy absorbed may be determined by difference. Such machines are the Fremont, the Olsen and the Hatt-Turner, the latter used extensively in tests of wood. (*Please turn to next page*)

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[1] Houwink, R., "Elasticity, Plasticity, and the Structure of Matter," 71–72 (1937).

[2] Kauzmann, W. and Eyring, H., "The Viscous Flow of Large Molecules," *Journal of the American Chemical Society, 62*, 3113 (Nov. 1940).

[3] Sayre, M. F., and Werring, W. W., *A.S.T.M. Proceedings of the Forty-First Annual Meeting*. Introduction to Symposium on Impact Testing, *38* Part II, 21 (1938).

[4] *Ibid.*, p. 21.

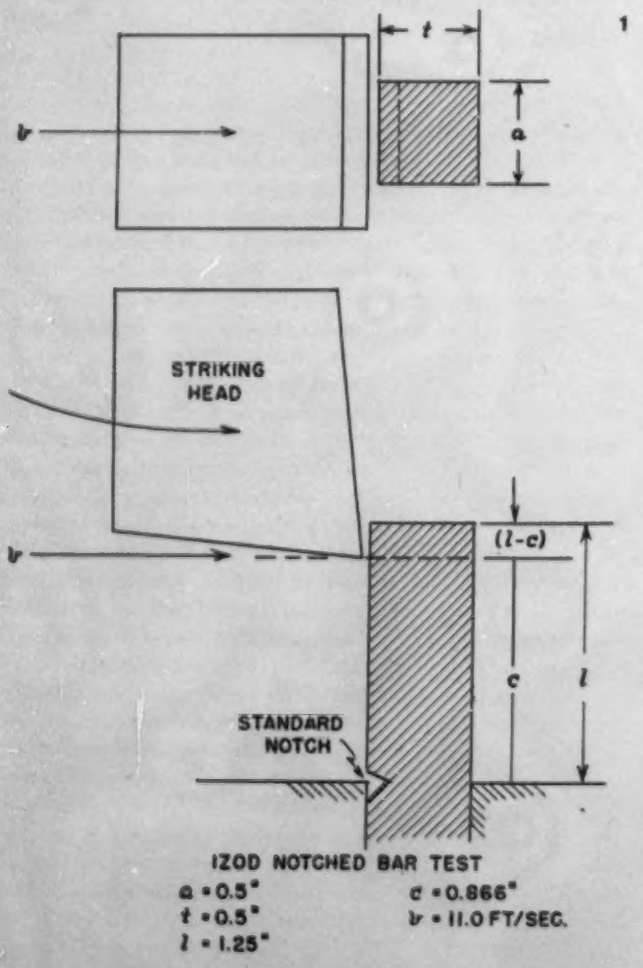
[5] Burns, R., and Werring, W., *A.S.T.M. Proceedings, 38*, Part II, 49 (1938).

[6] Callendar, L. H., "New Methods for Mechanical Testing of Plastics," Part I, *British Plastics, 13*, No. 155, 445–458 (April 1942).

4—*Pendulum impact machines*, several in number, have been developed. In these the specimen is broken by a single blow of a heavy, calibrated pendulum. The energy absorbed in the facture of the specimen is readily determined by calculation of the energy of blow indicated by the initial position of the pendulum and the remainder indicated by the highest position on the opposite side which is reached by the pendulum after breaking the specimen. Tests on the pendulum machines may differ in the design of the specimen and in the manner in which it is supported and struck. This gives rise to the following well-known tests: a) *the Charpy test*, in which a specimen, notched or plain, is supported at the ends and struck in the middle; b) *the Izod test*, in which a specimen, notched or plain, is supported at one end with the longitudinal axis of the specimen coincident with the plane of rotation of the pendulum; c) *the Oxford machine* is a pendulum machine of radical design in which both the specimen anvil and the tup are mounted on a pendulum. Both pendulums are supported only on wires with the intention of minimizing transmission and dissipation of energy through the machine to earth. The motions of both the anvil and the tup are recorded.

Many unsuccessful attempts[7] have been made to relate the impact energy values obtained to the cross section of the excess-swing pendulum test specimens. The practical advantage and convenience of such a relation would enable the manufacturer and consumer to test materials in the identical state in which they were used. Unfortunately, the shape and size of the notch in the testing of plastics are important considerations.[5,6,7] The magnitude of "notch sensitivity" within the field of plastics is not specifically dependent upon the structural characteristics of the two general types, thermoplastic and thermosetting resins.

1—*Diagrammatic relation of impact head and molded sample in standard Izod notched bar test*



5—*Flywheel machines* use a rotating flywheel as a source of energy for the fracture of the specimen. The knife edge or striking member is held within the rim of the wheel until the desired rotational speed is attained. The striking member is then extended and the specimen is engaged and broken in the next revolution. The *Guillery machine* is of the flywheel type arranged to break standard Charpy specimens rigidly supported in the usual manner. The velocity of blow is 29 ft. per second. The energy of the flywheel, both before and after fracturing the specimen, is indicated by a manometer reading of the output pressure of a small turbine coupled to the flywheel. The *Watertown variable velocity machine* is also one in which the energy of blow is generated by rotation of a flywheel and the specimen is struck by horns which are extended after the proper speed is attained. It differs from the Guillery machine in very fundamental ways. The flywheel furnishes the energy for rupture at a range of velocities up to 1000 ft. per sec., but is not involved in the measurement of energy values after the impact. The specimen is mounted upon a pendulum which is normally at rest. When the specimen is struck it imparts an impulse to the pendulum. The motion of the pendulum is indicated by a dial gage reading from which the energy absorbed by the specimen is derived by means of an elaborate mathematical analysis of the machine's energy relations. Papers have been presented by Mann[8] of the Watertown Arsenal on the subject of high velocity impact testing which show remarkable results. From the results of his test, on a machine of variable velocity which may be as high as 1000 ft. per sec., there seems to be a critical velocity beyond which the metal being tested seems to lose its impact resistance almost instantly. That is, as the velocity increases the impact strength will increase until a certain point is reached, whereupon the impact velocity drops nearly to zero. Callendar[6] shows the same effect in the increment-drop guillotine test for pure hard rubber sheet in much lower velocity ranges.

There are certain well-known limitations on the general applicability of specific notched-bar impact data in the testing of metals.[9, 10] A recent report[11] on the impact resistance and tensile properties of metals at subatmospheric temperatures bore the conclusions ". . . the notched-bar test does not in itself evaluate resistance to impact, but rather evaluates the response of a sample of specific dimensions, made of a given material, to the stress conditions set up in that specimen, which response depends in part on the ability to deform. The geometry of the specimen, as well as its material, influences the ability to deform. Hence when a small specimen of a given material shows good ability to resist impact stress applied to a notched piece, there is no assurance that a larger specimen, even though geometrically similar, will be tough..."

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[7] McAdam, D. J., and Clyne, R. W., "The Theory of Impact Testing," *American Society for Testing Materials, 38*, II, 116, 125 (1938).

[8] Mann, H. C., "High Velocity Tension-Impact Tests," *American Society for Testing Materials, 36*, II, 85 (1936).

[9] Hoyt, S. L., "Notched-Bar Testing," *Metals and Alloys, 7*, 5–7, 39–43, 102–106, 140–142 (1936).

[10] Hoyt, S. L., "Notched-Bar Testing of Steel," *A.S.M. Handbook*, American Society of Metals, 671–677 (1939).

[11] Gillett, H. W. (Editor), "Impact Resistance and Tensile Properties of Metals at Subatmospheric Temperatures," *American Society for Testing Materials*, 6 (1941).

Outline of test requirements

The specific problem in the impact testing of plastic sheets is the inability to use available methods of test for the testing of specimens in the form and thickness used in actual practice. Plastic sheet stock is normally used in thicknesses varying from 0.005 in. to 0.125 in. in the fabrication of watch and instrument crystals and dials, plastic bindings, plotting and drawing instruments, cockpit enclosures and a myriad of uses in which impact resistance is a prime requirement. Each item is generally small and in a form and application involving both manual and mechanical abuse. The plastic sheet stock is subjected to impact forces in the processes of: 1) fabrication of the finished article, in stamping, drawing, shearing and punching operations; 2) manual and mechanical abuse of the finished article in service.

It is necessary, therefore, that a method of testing impact strength be available for the manufacturer of plastic sheet stock in the production of a material that will satisfy the impact strength demands placed on the material in the fabrication operations and in service.

The foregoing survey of present impact testing methods reveals a number of generalizations that are significant in their lack of applicability in the testing of plastic sheet stock:

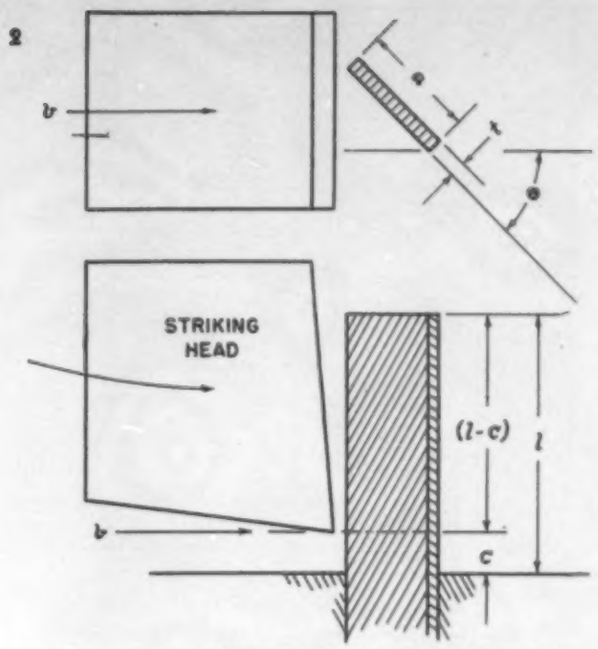
1—The specimens are molded or machined to definite specifications, limiting the use of variables in sample thickness in the sheets of finished form. The molded and machined samples, in themselves, are not representative of the material characteristics when that material is in another shape or in the form used in service.

2—The specimens, in several cases, are intentionally weakened by machined or molded notches. This artificial condition eliminates the use of the results in design work, for the one thing avoided in the design of finished plastic parts is incorporation of notch effects.

3—The notch-bar test, by common acceptance, does not in itself evaluate resistance to impact except through relative comparison of materials of widely varying structural characteristics. As accepted, the standard notched-bar impact test methods can effectively differentiate materials having brittle or non-brittle fractures, but the energy values required to produce such fractures are not necessarily significant.

4—The results are reported in the units of energy required to fracture samples of uniform and definite size. Attempts to correlate cross-section area and energy have been unsuccessful in notched-bar impact specimens.

5—The variable velocity flywheel machines show significant tendencies not so clearly revealed in the excess-swing pendulum machines. The velocity of impact appears to influence the impact energy values. Other types of impact tests have shown the influence of velocity of impact on the strength properties of metals,[12] as well as plastics.[13] Indeed, the term "velocity-sensitive" has joined "size-sensitive," "notch-sensitive" and "temperature-sensitive" in the nomenclature of impact testing.[14, 15] Plastics, in general, are "notch-sensitive." This condition limits the value of notched-impact



MODIFIED IZOD PENDULUM TEST
a = 0.5"
t = 0.005" TO 0.040"
c = 0.060"
l = 0.5"
θ = 30°, 45°, 60°
b = 1.5 TO 11.3 FT/SEC.

2—*Diagrammatic relation of impact head and sheet sample in the modified Izod excess-swing pendulum*

results obtained by the currently standardized Izod and Charpy excess-swing pendulums.

The elements of variable speed of impact and ability to deform are missing in the standard Izod and Charpy excess-pendulum methods of test. It is generally held that the stress required to produce a given deformation increases with the speed of deformation, and there is some evidence that the increment of stress can be very large.[16] The primary determinate in the condition of material toughness is the deformability of the material under impact. The critical rate of material deformation produced by stresses applied at variable rates of velocity, by inference, should determine the inherent resistance of the material to impact stresses. Consequently, the parameter of impact velocity (hence deforming rate), rather than energy required to cause rupture, appears to be the determinate in impact testing of rigid materials.

Figure 1 shows the diagrammatic relation of the sample and striking head in the standard Izod notched-impact test. The sample is not free to deform because of its rigidity and geometric proportions. The sample will always fracture under the influence of the swinging pendulum and impact head, because of an excessively high store of kinetic energy in the impact head.

A method of test for plastic sheets was visualized which:

1—Fractures the specimen only when and if the impact velocity is sufficiently high to cause failure.

2—Provides a means of allowing the specimen to deform when the critical impact or failure velocity is not exceeded.

3—Tests sheets of various thicknesses and expresses the results in terms related to any other sample thickness for a given material.

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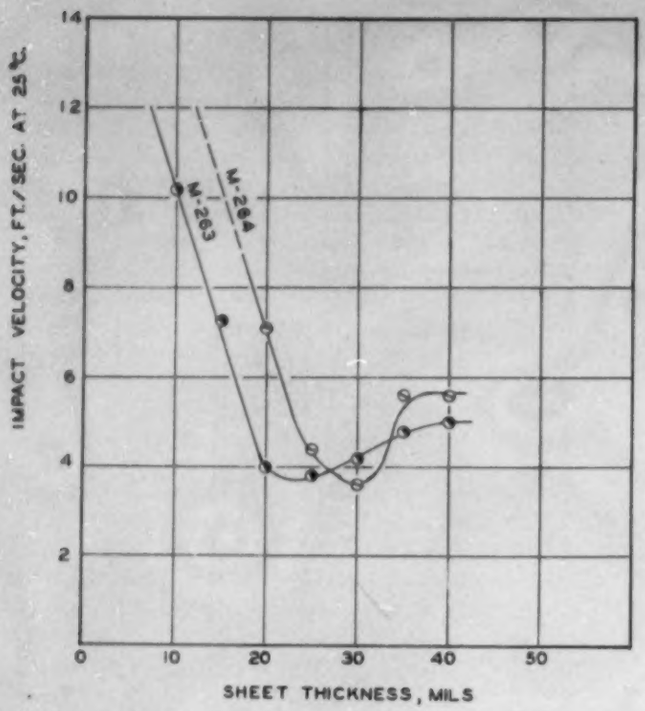
[12] Parker, E. R., and Ferguson, C., "The Effect of Strain Rate upon the Tensile Impact Strength of Some Metals," *Transactions of American Society of Metals, 30*, 68–69 (1942).

[13] Nitsche, R., Kuntze, W., and Mertens, H. V., *Kunstoffe, 30*, 193–9 (July 1940).

[14] Gillett, H. W. (Editor), "Impact Resistance and Tensile Properties of Metals at Subatmospheric Temperatures," *American Society for Testing Materials*, 6 (1941).

[15] Hoyt, S. L., "Notched Bar Testing and Impact Strength," *A.S.T.M. Proceedings of the Forty-First Annual Meeting*. Symposium on Impact Testing, *38*, Part II, 154 (1938).

[16] *Ibid.*, p. 149.



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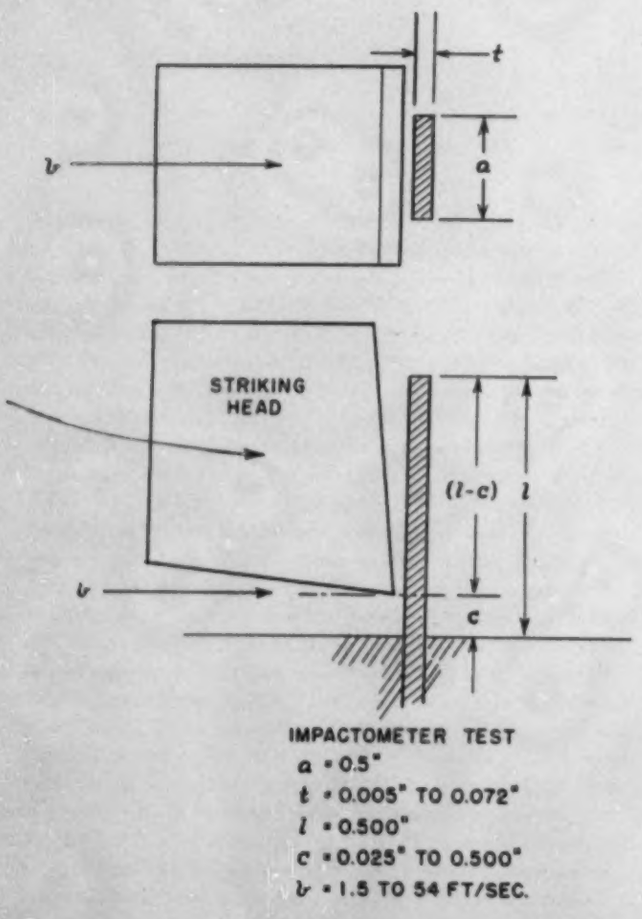

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3—Critical impact velocity vs. sheet thickness by method of test in Fig. 2 for two copolymer vinyl chloride-acetate sheets. 4—Diagrammatic relation of impact head and sheet sample finally adopted in the impactometer

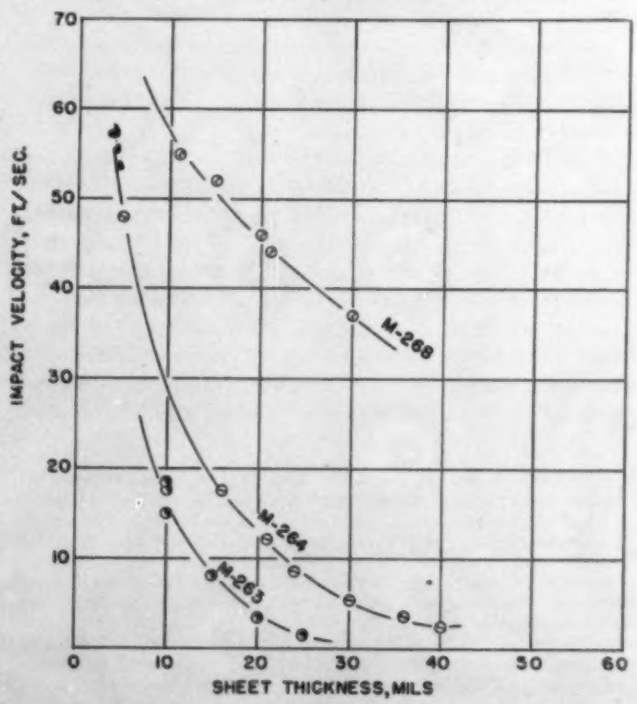
4—Subjects the sample to impact forces which resemble the type of abuse that the sheet stock normally receives in service.

Experimental methods and details

The Izod pendulum was modified and utilized in subsequent trials in the attempt to fulfill the requirements noted above. The development of the impact test was carried out by the use of rigid copolymer vinyl chloride-acetate sheet stocks with degrees of toughness known from previous service records. The data are presented for the vinyl copolymer compounds containing the same base resin and the various degrees of toughness displayed by the vinyl copolymer stocks noted are caused only by processing variations.

Strips, 0.5 in. in width, of rigid copolymerized vinyl chloride-acetate were fitted in a modified jig of the Izod pendulum in such a manner (see Fig. 2) that the longitudinal axis of the specimen was in the plane of rotation of the pendulum. The clearance, or distance between the leading edge of the impact head and sample jig, was standardized as 0.060 in. in the preliminary trials. The standard Izod impact head (A.S.T.M. D 256-34T) with an unrounded edge and striking face inclined 5° from the plane of the specimen was used. Trials have shown that a change in the inclination of the face of the impact head does not appreciably alter the results. A flat face, parallel to the plane of the sample at the instant of impact, produced no significant change in the impact velocity required to shatter the specimen. A specimen length of 0.5 in. was standardized as that part of the cantilever beam extending above the jig. The first trials were determined on sheet samples, the planes of which were fixed at an angle of 45° with the plane of rotation of the pendulum. The linear velocity of the impact head, at the instant of impact, was calculated from the corresponding initial angle of rotation of the pendulum. Separate specimens of the sheet stock were clamped in the jig and struck by the swinging pendulum at variable and increasing impact velocities. A new specimen

5—Critical impact velocity vs. sheet thickness by method of test shown in Fig. 4 for three copolymer vinyl chloride-acetate sheet stocks, clearance 0.100 in., 25° C.



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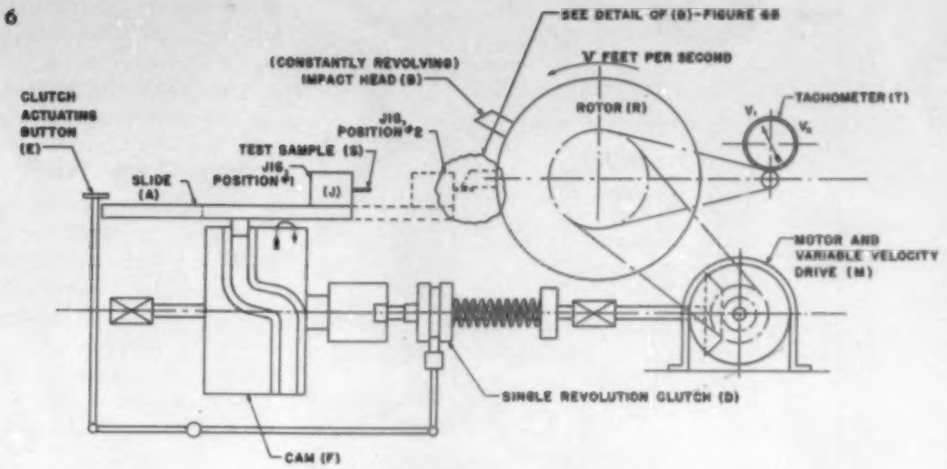

DIAGRAMMATIC PRINCIPLE OF THE IMPACTOMETER

6—Operation of impactometer shown in detail

was clamped in the jig at each setting of the pendulum. It was noted that low impact velocities of the pendulum caused the sample to deflect as the impact head passed on its arc of swing. As the initial height of the pendulum was increased, thus increasing the consequent linear velocity of the striking head at the instant of impact, rupture of the specimen occurred at the junction of jig and sample. The limiting range of impact velocities producing all bends or all shatters was fairly critical.

A definite increase in the number of shatters in 10 samples tested at each velocity was produced by a passage from the minimum velocity causing the first shatter through the velocity range to that producing all shatters. The impact velocity causing the statistical average of 5 shatters in 10 samples tested was established as the "impact velocity" for the specific sheet stock in the given thickness and under the standard conditions of test. It was shown that the correlation of sample thickness with the corresponding impact velocity produced a curve characteristic of the stock tested. Figure 3 shows the impact velocity versus sample thickness for two typical commercial copolymer vinyl chloride-acetate sheet stocks. The flat sheet samples were fixed at an angle of 45° with the plane of rotation of the pendulum as shown in Fig. 2.

At low sample thicknesses, the relation of the flat impact head to that of the flat sheet sample at an angle of 45° caused a twist and shear on the specimen at the instant of impact and rupture. As the sample thickness was increased the rigidity of the specimen was increased, which restricted the torque on the sample at the instant of impact. The inflection of the curve in Fig. 3, beginning at the 20-mil thickness range confirmed the visual observation of the effect of sample thickness on its corresponding behavior when struck by the impact head. The rapid inflection in the curve for increasing sample thickness, beginning at the 20-mil range, is apparently caused by the increase in rigidity and consequent change in the stresses produced by the combined torque and flexure in the thicker samples. The use of angles of 30° and 60° rather than 45° for θ changed the location of the inflection on the thickness ordinate, but the influence of torque and "whip" was still shown in the thicker samples.

The thickness versus velocity curve was characteristic of any one type of copolymer vinyl chloride-acetate sheet stock, and the impact velocity results for any given thickness were predictable. The inherent weaknesses of the Izod pendulum and the sample relations shown in Fig. 2 were the discontinuity in the range of increasing sample thickness and a limited velocity range of the pendulum because of the mechanical limitations of the machine itself.

The fixing of the sample in the jig, as shown in Fig. 4, removed the inflections to produce the smooth curves shown in Fig. 5. Consequently, further work on the variable velocity impact test was carried out with the specimen fixed in the position shown in Fig. 4.

With this background, a flywheel machine was designed and built employing the sample and impact head relationship shown in Fig. 4. For want of a better name for the instrument, the term "impactometer" was used. The limited impact velocity of 11.3 ft. per sec., the highest attainable on the Izod pendulum, was increased to 54 ft. per sec. maximum in the impactometer.

The principle of operation of the impactometer consists of a single high-velocity impact blow directed on a strip of rigid plastic sheet stock fixed and extended as a cantilever beam. The actual force required to initiate or continue rupture is not considered. The sample is free to deform and deflect if the magnitude of the impact velocity is insufficiently high to cause rupture.

The diagrammatic plan of the impactometer is shown in Fig. 6. In brief, the test specimen (*S*) is rigidly fixed in the vise or jig (*J*) which is bolted on the slide (*A*) located in a slotted track. The slide (*A*) is actuated by a dog in the cam (*F*) rotated by the cam shaft through a single revolution clutch at (*D*). The motor and variable velocity drive (*M*), geared to the cam and clutch mechanism, also belt-drives the heavy cast iron rotor (*R*). On the rim of the rotor is rigidly fixed the impact head (*B*). The detail of the impact head dimensions and manner in striking the sample is shown in Fig. 7. The tachometer (*T*), driven from the rotor shaft, is calibrated in feet per second linear velocity of the impact head (*B*).

In operation, the rotor (*R*) is continuously revolving at a constant velocity (*V*) which can be varied. The sample, of known thickness and width of 0.5 in., is clamped in the jig at position No. 1 as a cantilever beam of 0.5 in. length. The cam (*F*) is caused to engage the cam shaft through the clutch actuated by the clutch control (*E*). The cam makes only one revolution which carries the jig and sample into the arc of rotation of the impact head. The dwell on the jig and sample, at position No. 2, is only sufficiently long to allow the impact head to strike the sample in one revolution of the

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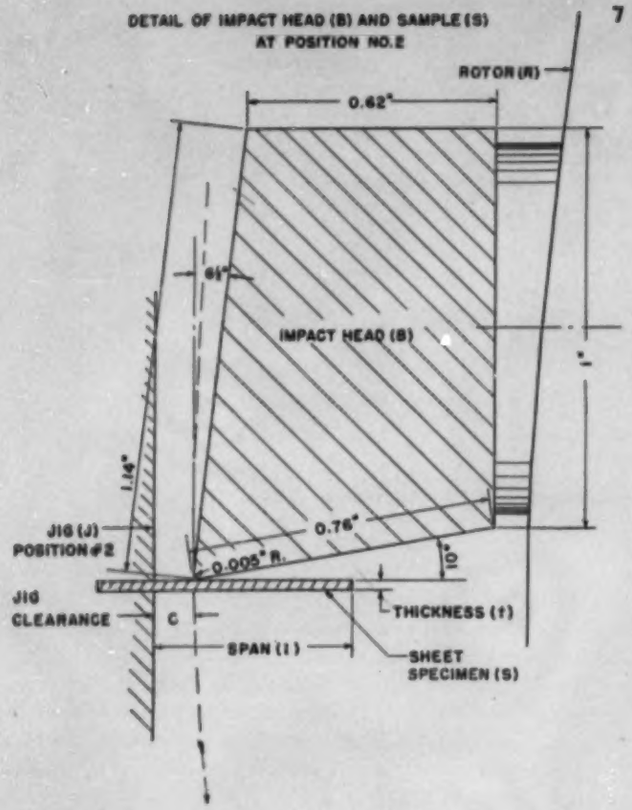

7—Detailed diagram of impact head and specimen. 8—Detail of sample, jig and impact head at start of cycle, position 1. 9—Detail of sample, jig and impact head at instant of impact, position 2. 10—Impactometer in use, with moving parts hooded as a safety measure

rotor. The sample, struck by a single impact of the rotating head, is removed from the arc of rotation of the impact head by the return of the jig and slide to the original position No. 1. The rotor, impact head, sample and jig in the slide are shown in the photograph in Fig. 8. The details of the impact head and sample, at the instant of impact, are seen in Fig. 9.

At low impact velocities the sample is merely bent. As the impact velocity of the rotor is increased, a critical velocity is finally attained where the new samples of the sheet stock are severed at the junction of the jig and the sample. In actual operation of the impactometer, 10 samples of the same sheet stock are tested at each velocity setting of the rotor. The number of shatters in 10 trials, at each velocity setting of the rotor, determines the magnitude of the critical velocity limits v_0 and v_{10}, i.e., the linear velocity below which all the 10 trials are bends and above which all of the 10 trials result in fracture, respectively. The mean impact velocity, v_5 (see Fig. 11), between the critical limits is the point where an average of 5 samples out of 10 tested, are fractured. The method of determination of the statistical mean impact velocity for a specific copolymer vinyl chloride-acetate sheet stock, in two thicknesses, is shown in Fig. 11.

The impactometer is shown in operation in Fig. 8. .All moving parts are hooded as a safety measure. The sliding door through which the sample is inserted and fixed in the jig is an additional safety measure. The clutch mechanism is operated by a relay circuit switch and solenoid. The electrical circuit is automatically broken by a secondary switch as the door is opened, which prevents the operator's hand from being carried into the range of the impact head on accidental operation of the clutch mechanism. Consequently, the clutch mechanism cannot be operated by the relay switch until the safety door is closed completing the electrical circuit.

Data and results

The diagrammatic relation of the specimen and the impact head of the impactometer is shown in Fig. 12. The vector analysis of the impact velocity results for three rigid copolymer vinyl chloride-acetate sheet stocks are shown. As would be expected, the critical velocity for a specific sheet stock is dependent upon the sheet thickness and the clearance between the striking head and the sample jig. A clearance of 0.100 in. was standardized. It was found that the 0.100-in. clearance limited the useful range of the machine for certain

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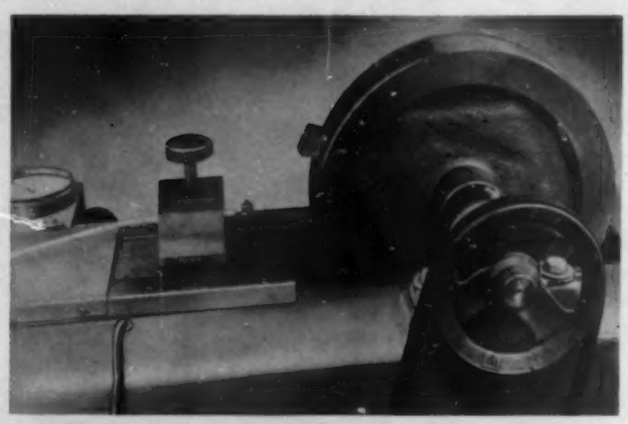

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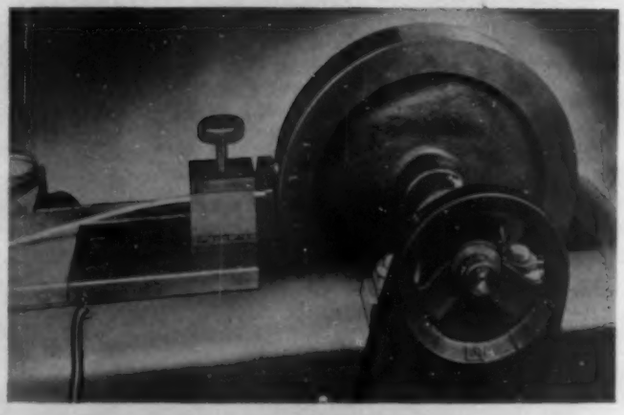

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stocks. For example, thick sheets of a relatively brittle stock could not be tested at low temperatures at the 0.100 in. clearance setting. Accordingly, variations in clearance were calibrated with respect to sample thickness for specific sheet stocks. The principles of dimensional analysis were utilized to reveal a characteristic behavior in the impact velocity results influenced by variations in jig clearance and sample thickness. The two variables of jig clearance and sheet thickness were combined in the expression

$$\sqrt{\frac{c}{t}} \qquad (1)$$

where c is the jig clearance and t the sample thickness expressed in thousandths of an inch.

Within certain limits, determined by the minimum clearance where failure was caused by rupture by impact and not by mechanical shear, the relation of impact velocity, v, jig clearance, c, and sample thickness, t, was satisfied by the expression

$$v = k_1 \sqrt{\frac{c}{t}} - k_2 \qquad (2)$$

The value of k_1 is determined by the inherent toughness of all thicknesses of a specific material and the value of k_2 is determined by the mechanical characteristics of the machine which are essentially constant for all of the various types of plastic sheet stocks tested. The above relation was utilized in the testing of stocks, varying widely in relative impact resistance, which could not be tested at the standard jig clearance of 0.100 inch.

The effect of temperature on the brittleness of natural and synthetic rubber at sub-zero temperature has been reported.[17] The method of test is of special interest because of the similarity to the impactometer herein described. The "brittle points" of unplasticized polyvinyl chloride and polystyrene sheet stock were determined by Selker and his co-authors by the use of a flywheel carrying the frozen specimen which was suddenly struck by a fixed impact head. The correlation of the ratio as shown in Equation 1 for frozen rubber specimens and rigid polymers evaluated in the Selker test method are in close agreement with the same ratios determined by the impactometer for various plastic sheet stocks. The "brittle points" determined by Selker *et al.*, were obtained at constant velocity and variable temperature, whereas the impactometer results are reported as a variable impact velocity at constant temperature. The relations are significantly similar in the two methods of test, even though the two test methods were developed for the determination of different properties in polymeric materials under dissimilar conditions of test.

As shown in Fig. 5, the expression of the curve is given by:

$$v = k_3 e^{-k_4 t} \qquad (3)$$

where v is the impact velocity, e is the natural logarithm base, t is the sample thickness, and the constants k_3 and k_4 are dependent upon the mechanics of the test method and the specific toughness of all thicknesses of any one sheet compound, respectively. Converting Equation 3 to the logarithmic form gives:

$$\log v = k_3 - k_4 t \qquad (4)$$

Equation 4 was utilized to show the logarithm of impact velocity as a straight-line function of sample thickness. Plotted on this basis, the data shown in Fig. 13 allow the ready correction for sheet thickness. The slope of the line k_4 expresses the inherent toughness of any one sheet compound in all thicknesses.

[17] Selker, M. L., Winspear, G. G., and Kemp, A. R., "Brittle Point of Rubber on Freezing," *Ind. Eng. Chem., Ind. Ed.*, *34*, 157–160 (Feb. 1942).

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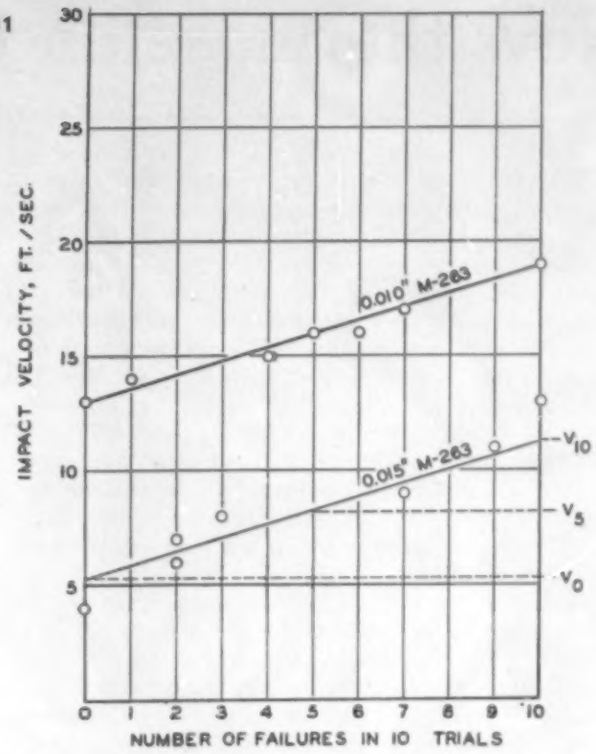

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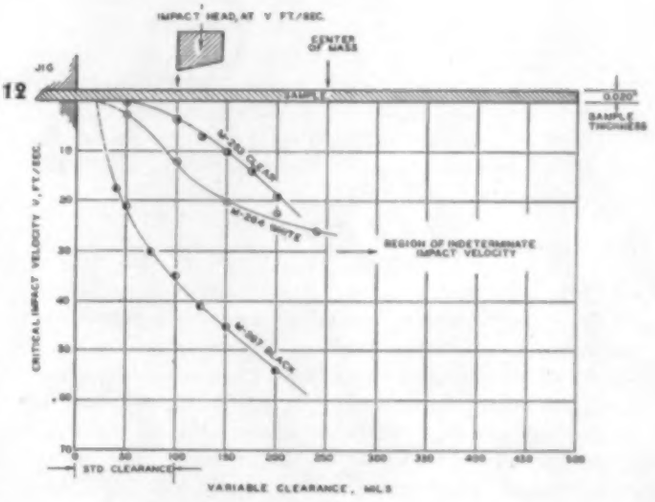


11—*Determination of average impact velocity for two thicknesses of a copolymer vinyl chloride-acetate sheet in accord with Fig. 4. Clearance 0.100 in., 25° C.* **12**—*Effect of variable jig clearance for three copolymer vinyl chloride-acetate sheet stocks at 25° C.*

Figure 13 (page 116) shows impact velocities for a series of rigid sheet compounds of copolymer vinyl chloride-acetate resins in various sample thicknesses. The relative degrees of toughness of the compounds shown are indicated by the magnitude of the impact velocity. The validity of the test results shown has been confirmed in actual service and in supplementary tests involving severe abuse similar to that received in actual service. The supplementary tests involved the destruction of fabricated assemblies under repeated hammer blows, the shearing (*Please turn to page 116*)

New thermosetting compounds

COLUMBIA resins* comprise a broad family of chemical compounds which show unusual promise as colorless, transparent, thermosetting synthetic materials in the plastics field. The individual members of the series are all chemical entities which, for the sake of simplicity, are designated by numbers. Those of the group which have been prepared and tested differ from one another in specific properties, the family covering a very wide range in reactivity, hardness, strength, flexibility and general resistance to deteriorating influences. Variations of these properties are made, not by the addition of plasticizers, but by adjustment of the chemical structure of the molecules of the resin monomer. Commercial development is, for the present, being concentrated on C.R. 39 because it possesses general properties which are believed to be most widely in demand.

Monomeric C.R. 39 is a clear, colorless liquid of low viscosity containing only carbon, hydrogen and oxygen. It is stable at ordinary temperatures, but upon heating in the presence of a catalyst, such as benzoyl peroxide, it passes through an induction period, then gradually increases in viscosity until it gels. Upon the application of further heating the gel hardens and finally becomes a strong, hard, insoluble, infusible crystal-clear, colorless to slightly yellow solid. The monomer is thus converted into a thermohardened resin by a simple polymerization process without the evolution of water, ammonia or any other by-product, and not by a condensation process as is common in conventional thermosetting materials. This, together with the inherently low volatility of the monomer, makes possible the use of the resins in fabricating processes without the application of high pressures.

Clear cast sheets

The pure material is cast-polymerized, under suitable conditions, into transparent sheets having certain outstanding characteristics. Compared with other transparent plastics, it offers the advantages of not crazing when held under stress, of extraordinary resistance to chemicals and solvents, of greatly increased mar and abrasion resistance, and of much greater resistance to distortion under heat. Its weight, strength, shock resistance and ease of forming into bent shapes are comparable to those of other transparent resins. The cast sheets burn at about one-third the rate of the methacrylates. While the sheets are extraordinarily clear and weather-resistant, they do yellow slightly upon prolonged exposure to ultraviolet light. This small discoloration is not accompanied by any substantial decrease in clarity or light transmission and there is good reason to believe that it will soon be eliminated completely.

These sheets are somewhat more brittle than corresponding methacrylate sheets at room temperature, but they are less brittle at low temperatures (−40° F. to −70° F.). In bursting strength (ability to withstand gas pressure over large areas), breaking strength (ability to withstand a falling steel ball) and shock resistance, the cast sheets compare favorably with the methacrylates. Pendulum type impact tests show that the transparent resin has substantially the same strength as the methacrylates with notched specimens, but lower strength when unnotched bars are used.

C.R. 39 has been reported to be an extremely good photoelastic material. It does not exhibit any optical creep—that is, when the load is removed no part of the stress pattern remains, up to nearly the ultimate stress of the material. The optical sensitivity (86.6 p.s.i./fringe/inch thickness) compares well with other photoelastic materials and the fringes are more distinct.

In the common machining operations, such as sawing, turning and drilling, the greater brittleness of the resin at room temperatures is noticeable. When this is taken into account and suitable tools and methods are applied, it is easily possible to perform all these machining operations without too much difficulty.

The infusible character of the resin facilitates operations in which heat is developed, such as sawing, sanding, grinding, polishing and buffing. These may be done at high speeds, without coolants, and without the tendency to drag, fuse or gum that is sometimes encountered in the methacrylates.

Fully cured sheets can be formed by heat to fairly severe, simple curvatures, and moderate compound curvature, but cannot be subjected to deep draws over large areas. Conventional plastic-forming equipment is used. These sheets show remarkably little tendency to distort or to develop surface defects in the heating and forming operations. They are

* Developed by Columbia Chemical Div., Pittsburgh Plate Glass Co. This material is not yet available for commercial use.

NOTES TO TABLE I

(a) The Knoop indentor (U. S. Patent No. 2,091,995) is described in National Bureau of Standards Research Paper RP-1220 and is incorporated in the Tukon tester now manufactured by the Wilson Mechanical Instrument Co., New York City.
(b) The impressor is a portable brand instrument in which an indenting point is activated through a graduated spring. It was announced in Ind. and Eng. Chem., News Edition, 384 (March 25, 1941). It is manufactured by the Barber-Coleman Co., Rockford, Ill. The dial reading was noted as soon as the load was applied to the point and again 15 sec. later. The latter reading was recorded as hardness and the difference between the two as cold flow.
(c) A 1000-lb. load was applied through two 1-in. diameter flat anvils to a 1/2-in. cube of the plastic. Decrease in cube thickness was measured after 24 hr., using a dial gage.
(d) Test specimens were abraded by rotating them at 78 r.p.m. under a 3/8-in. felt pad filled with No. 302 emery under a load of 76 grams. Abraded specimens were compared visually and the abrasion values calculated as: Revolutions used to abrade specimen/Revolutions needed for equivalent abrasion of methacrylate resin.
(e) In a modification of the Gardner test for the abrasion resistance of point film (Physical and Chemical Examination of Paints, Varnishes, Lacquers, and Colors, 9th Edition, 128) specimens were abraded by letting weighed amounts of No. 60 emery fall on them at an angle of 45° from a funnel through a vertical tube 6 ft. long and 1 in. in diameter. Abraded specimens were compared visually and the abrasion values expressed in two ways: (1) Weight of emery used to abrade specimen/Weight of emery needed for equivalent abrasion of glass; (2) Weight of emery used to abrade specimen/Weight of emery needed for equivalent abrasion of methacrylate resin.
(f) A.S.T.M. test D651-41T.
(g) The modulus of elasticity was calculated from the deflection observed under one-half the breaking load.
(h) A.S.T.M. test D638-41T, A.S.T.M. Standards, 1941 Supplement, Part III, 457.
(i) A.S.T.M. test D250-38, A.S.T.M. Standards, 1939, Part III, 252.
(j) A 1/2-lb. steel ball was dropped from increasing heights until the specimens failed. Data shown are for greatest drop that specimens withstood. All specimens were 3/16 × 15 × 20 inches. Curved specimens were bent to an 18-in. radius along the 15-in. dimension.
(k) Expansion of a specimen about 3 in. long supported vertically by a Pyrex holder in an air batch surrounded with a well-stirred liquid bath was measured with a dial gage.
(l) The thermal conductivity determination was based on the measurement of the change of temperature of a receiver of known thermal capacity due to a constant temperature source applied to a given area and thickness of plastic. The Cenco-Fitch apparatus was used.
(m) A.S.T.M. test D648-41T.
(n) The heat distortion test was carried on with continuous measurement of the deflection until either the specimen softened or until a temperature of 130° C. (266° F.) was attained.

TABLE I.—PROPERTIES OF COLUMBIA RESIN 39

Properties of monomer	*C.R. 39*	*Methyl methacrylate*	
Boiling point, ° C	160 (2 mm.)	100 (760 mm.)	
Refractive index, n_D, 20° C	1.450	1.415	
Specific gravity at 25° C	1.133	0.945	
Properties of clear cast polymer in form of transparent sheet	*C.R. 39*	*Cast methacrylate*	*Plate glass*
Specific gravity	1.32	1.19	2.5
Refractive index	1.505	1.49	1.52
Hardness:			
Knoop (a)	15–18	18–20	Approx. 400
Barcol impressor, 15 sec. (b)	28–31	....	
Rockwell—M scale	*92–94	*85–105	
H scale	*68	*60–65	
Cold flow:			
Barcol impressor, 15 sec. (b)	5–9	13	None
Plastic yield, 1000 lb. 1/2-in. cube (c):			
Room temperature	*.006″	*.005″	None
+50° C.	*.022″	*.075″	None
Abrasion resistance:			
Rotary, X methacrylate (d)	20–30	1	500
Falling emery (e)			
X methacrylate	8–10	1	10
X glass	0.8–1.2	0.1–0.15	1
Flexural strength, p.s.i. (f):			
50° C. (122° F.)	5000–6000	9000–11,000	
25° C. (77° F.)	8000–10,000	13,000–15,000	6500
−10° C. (14° F.)	13,000–15,000	13,000–17,000	
Modulus of elasticity in flexure, p.s.i. × 10^5 (f) (g):			
50° C. (122° F.)	1.6–2.0	2.5–3.0	
25° C. (77° F.)	2.8–3.5	3.7–4.5	100–110
−10° C. (14° F.)	4.3–4.6	4.0–4.6	
Deflection at break in flexural test, mils (f):			
50° C. (122° F.)	200–250	Cold flow	
25° C. (77° F.)	200–250	250–400	0.6
−10° C. (14° F.)	160–180	160–200	
Tensile strength, 25° C. p.s.i. (h)	6000	7500	6500
Impact strength, 25° C. ft./lb. per in. (i):			
Izod, notched	0.4–0.5	About 0.5	
Charpy, notched	0.4–0.5	0.5–0.55	
Izod, unnotched	2–3	About 5	
Charpy, unnotched	5–6	About 7.5	
Break limits, 1/2 lb. steel ball, free fall in feet (j):			
Flat specimens − 70° F.	42	18	
− 40° F.	42	21	
0° F.	45	21	
+ 32° F.	36	18	
+ 70° F.	33	18	
+120° F.	18	12	
Curved specimens − 70° F.	39	26	
− 40° F.	45	21	
0° F.	36	21	
+ 32° F.	33	24	
+ 70° F.	42	21	
+120° F.	21	18	
Thermal expansion linear coeff. per °C., × 10^{-5} (k):			
−40° C. to −10° C.	7.2	6.8	
−10° C. to +25° C.	8.9	8.1	0.8
25° C. to 50° C.	10.9	9.8	
Thermal conductivity (l):			
Cal./sec. cm./° C.	*5 × 10^{-4}	*4 × 10^{-4}	23 × 10^{-4}
B.t.u./hr./ft.²/in./°F.	*1.45	*1.16	6.67
A.S.T.M. heat distortion test 10 mils distortion temp. (m):	56–68° C.	68° C.	
Distortion at 130° C., mils (n):	35–70	Flows	
Maximum recommended operating temp. under no load:			
Continuous service	80° C. (176° F.)	70° C. (158° F.)	
Intermittent (1 hr. duration), °C.	150° C. (302° F.)	80° C. (176° F.)	

(Table continued on next page)

TABLE I.—PROPERTIES OF COLUMBIA RESIN 39 (*Continued*)

Properties of monomer	*C.R. 39*	*Methyl methacrylate*	
Burning rate, 1/8" sheet, Navy test, in. per min. (o)	0.35	1.1	0
Warpage, Navy test, after 48 hr. at 60° C., in. (p)	0.00	0.00	None
Light transmission before aging:			
White, % (q)	95–96	96	
Blue, % (r)	90–91	92	
Haze before aging (q)	1–2	1–2	
Light transmission after aging (s):			
White, % (q)	94–95	96	
Blue, % (r)	77–82	89	
Haze after aging (q)	1–2	1–2	
Water absorption:			
Navy test, % (t)	0.2	0.2	
A.S.T.M. test, % (u)	0.2–0.4	0.3	
Power factor (v):			
1 Kc	*0.0123		
1 Mc	*0.0536		
Dielectric constant (v):			
1 Kc	*3.92		
1 Mc	*3.74		
Dielectric loss (v):			
1 Kc	*0.0482		
1 Mc	*0.20		
Dielectric strength (w):			
Short time volts/mil	*354		
Step by step volts/mil	*290		
Resistance to chemicals (x):			
Gain, in weight after 7 days' immersion, %			
Distilled water	0.8	0.7	
30% sulfuric acid	0.5	0.3	
3% sulfuric acid	0.7	0.6	
10% nitric acid	0.7	0.5	
10% hydrochloric acid	0.6	0.5	
10% ammonium hydroxide	1.1	0.6	
10% sodium hydroxide	0.1	0.5	
1% sodium hydroxide	0.7	0.6	
2% sodium carbonate	0.8	0.6	
1% sodium chloride	0.65	0.5	
3% hydrogen peroxide	0.9	0.7	
95% ethyl alcohol	0.3	11.0	
50% ethyl alcohol	0.2	3.4	
Acetone	1.4	Soluble	
Ethyl acetate	0.7	Soluble	
Carbon tetrachloride	0.0	−2.4	
Chloroform	1.6	Soluble	
5% acetic acid	0.8	0.7	
Gasoline	0.02	0.0	
Oleic acid	0.3	0.2	
Benzene	0.2	Soluble	
Toluene	0.2	Soluble	

Note: A new Columbia resin, C.R. 38, now being developed, has power factors at 60 cycles and radio frequencies similar to those of the phenol-formaldehyde resins. Its dielectric strength and arc resistance will excel even the urea-formaldehyde resins. When laminated, it is more flexible than either the phenolic or urea resins

(o) Test for Flammability, Navy Aeronautical Specification P-41C, Sec. F-3e.
(p) Test for Warpage Due to Elevated Temperature, Navy Aeronautical Specification P-41C, Sec. F-3i.
(q) White light transmission and haze values before and after aging were measured with a hazemeter of the kind described by Axilrod and Kline, Journal of Research of the National Bureau of Standards *19*, 370 (1937). Specimens 1/8 in. thick. Transmission values are higher than theoretical and require correction back to 92 percent.
(r) Blue light transmission was measured with a Cenco-Sheard-Sandford photolometer fitted with a dense blue, Cenco No. 1, filter. Specimens 1/8 in. thick.
(s) Aging was accomplished by a modification of the method described by Kline, Crouse and Axilrod in MODERN PLASTICS *17*, 49 (Aug. 1940), in which specimens were exposed for 200 hrs. in a horizontal plane 7 in. below an S-1 bulb in a BM6 sun lamp with two 2-hr. periods in a fog chamber each day.
(t) Test for Water Absorption, Navy Aeronautical Specification P-41c, Sec. F-3j.
(u) A.S.T.M. test D570-40T, A.S.T.M. Standards, 1940 Supplement, Part III, 292.
(v) Power factor, dielectric constant and dielectric loss were determined at 1 kc. and 1 mc. using a GeneralRadio Power Factor Bridge.
(w) Dielectric strength was determined by the methods described in paragraphs F-2V(8) and F-2V(9) of Bureau of Ships Specification 17 P8 (INT) of April 1, 1941.
(x) A.S.T.M. test D543-41T, A.S.T.M. Standards, 1941 Supplement, Part III, 452.

not easily damaged by overheating in the oven. In some cases, where exceptional form stability is required, it may be desirable to form cast sheets while they are in an undercured, flexible condition and to complete their curing in the mold during the forming operation. This procedure, while more time-consuming than ordinary forming, yields products which retain their curvature on aging, though not confined in frames.

Table I is a compilation of the current data on the physical, electrical, optical and chemical properties of transparent C.R. 39. Data for cast methacrylate plastics as determined in our own laboratory are included for comparison, because results obtained in different laboratories, even by standard methods, sometimes show considerable variation. Most of the values shown for glass were taken from the literature. This was made necessary by the limitations of most plastic testing machines. Data marked with an asterisk were determined by laboratories other than Columbia's own. All data are subject to future change to allow for refinements in testing technique and for improvements in the product which will undoubtedly result from continued research. (*Please turn to page 120*)

Plastics from hydrolyzed lignocellulose*

by RAPHAEL KATZEN,† A. O. REYNOLDS‡ and DONALD F. OTHMER†

IN a recent paper,[6] two of the authors have described a new process which has been developed for the continuous hydrolysis of wood and other plant fibers to give lignocellulose for use in plastic molding compounds. The data presented give some indication of the advantages of this material over hydrolyzed lignocellulose produced by batch processes; and these advantages have been borne out in the subsequent work on compounding and molding, to be described in this report.

The hydrolyzed lignocellulose was all produced by the operations of mixing, hydrolysis, washing, drying, grinding, blending, rolling and re-grinding, as indicated on the flow sheet (Fig. 1), the first part of which was presented previously. A study of this flow sheet will facilitate an understanding of the manufacture of the material worked with.

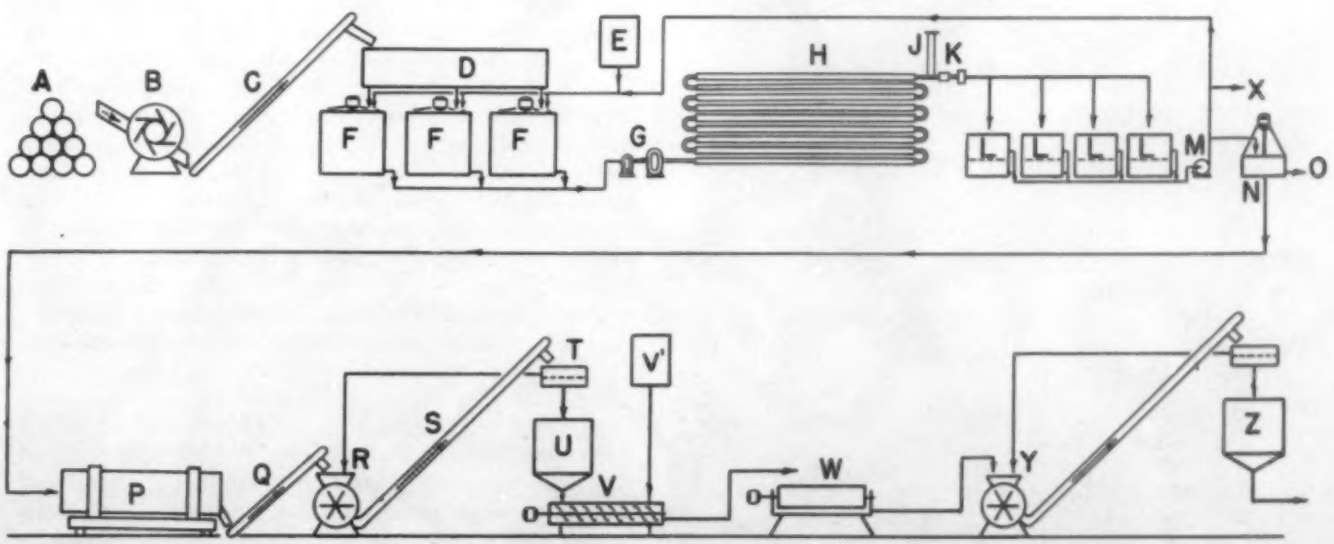
Operations involved. In Fig. 1 there is a flow sheet of the several steps required for converting wood to lignocellulose and compounding this with other materials. Wood supply (*A*) is reduced to appropriate size in chipper (*B*), or finely divided waste such as sawdust may be used directly. Conveyer (*C*) takes it to storage bin (*D*). A small tank (*E*) is also required for intermediate storage and metering of sulfuric acid. Wood chips, water and sulfuric acid are mixed in wood tanks (*F*) equipped with agitators. From the tanks, the suspension is passed by pumps (*G*) to hydrolysis tubes (*H*), where it is heated to the desired temperature. A surge chamber (*J*) tends to equalize pressure variations caused by the action of the pumps. A discharge valve (*K*) is set so as to release hydrolyzed suspension from the tubes to atmospheric pressure. The suspension then passes to filter tanks (*L*) equipped with false bottoms to permit drainage of liquors. Part of the liquor is recycled to the mixing tanks for reuse in hydrolysis, by pump (*M*). Part may be taken off for by-product recovery (*X*). Washing and pH adjustment are also carried out in these tanks. Final dewatering is accomplished by passing a suspension of the washed lignocellulose to centrifuge (*N*). Water is drained off to waste (*O*) from the centrifuge.

Centrifuged filter cake is passed to rotary dryer (*P*) heated by steam or hot flue gases from the boilers. Dried lignocellulose is passed by conveyor (*Q*) to grinder (*R*), thence by another conveyor (*S*) to shaking screen (*T*). Oversize is returned to the grinder, while ground lignocellulose is passed to storage bins (*U*). From there it is taken to be mixed with appropriate amounts of resin, dye, lubricant, moisture, etc., from storage bin (*V'*) in a dry blender (*V*), before being compressed on the rolls (*W*). Rolled sheets are crushed in a hammer mill (*Y*) and screened on shaking screen (*Z*), oversize being returned to the hammer mill. Screened molding compound is then packaged for shipment to the molder.

As the hydrolysis variables have been described and discussed previously, only the secondary compounding operations will be discussed hereafter.

Resins in compound. Lignocellulose produced by continuous hydrolysis has been compounded with various resins, both thermoplastic and thermosetting. After a study of the inherent properties of ligneous materials, it was decided that their fundamentally phenolic nature and relatively dark color indicated that they should be used in conjunction with phenolic resins in thermosetting molding compounds. An excellent review of the required properties of fillers for such plastics has been published recently.[5] Many experiments with various types of phenol-formaldehyde and phenol-furfural resins narrowed the field to a consideration of the use

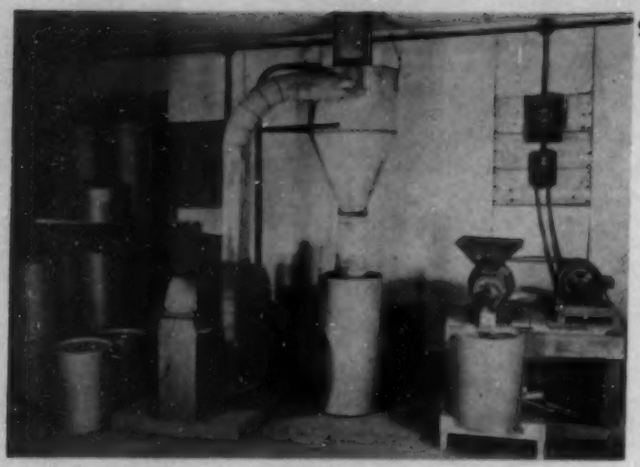
1—*Flow sheet of hydrolysis and compounding operations*

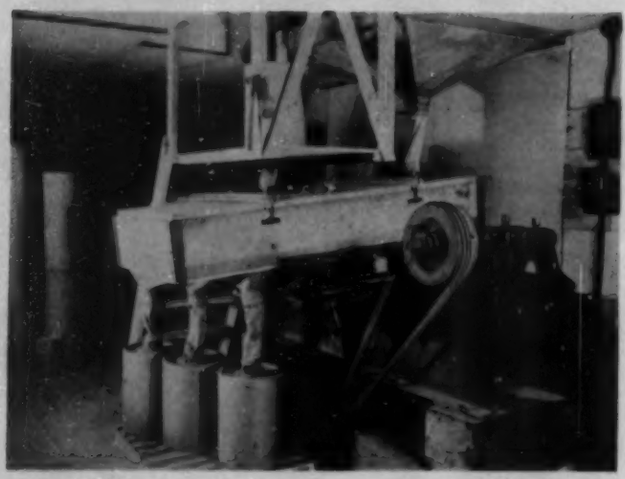


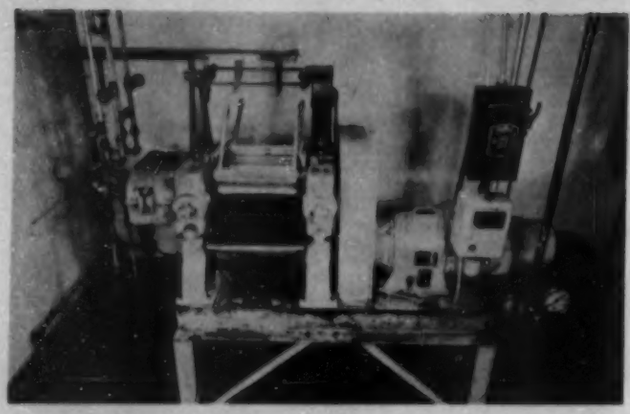
* This paper was presented before the American Institute of Chemical Engineers in Boston on May 12, and is published here by permission of that organization (cf. Trans. A.I.C.E., Vol. 38, No. 5, Aug. 25, 1942).

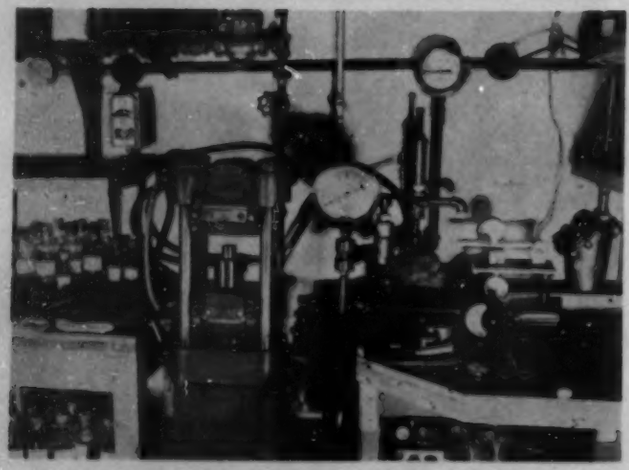
† Polytechnic Institute of Brooklyn.

‡ Northwood Chemical Co.









(in conjunction with hydrolyzed lignocellulose) of two-stage resins, preferably containing a slight excess of phenol and a catalyst (usually hexamethylenetetramine). Although the exact specifications of these resins are trade secrets of the individual manufacturer, it may be said that this type of phenolic resin, when used with hydrolyzed lignocellulose, yields a material having compounding and molding characteristics desired in current practice.

Catalysts, plasticizers and lubricants in compound. Addition of catalysts to the molding compound is not necessary if the resin contains a slight excess of hexamethylenetetramine. As this catalyst is quite commonly encountered during synthesis of two-stage resins, it is necessary only to determine whether or not further catalyst is required. This is also true of plasticizers, which are already incorporated in many resins. In the compounding of hydrolyzed lignocellulose-filled phenolics, however, it is desirable to have a small amount of water present to act as a fluxing agent during the compounding operation; the molding operation and the physical properties of the finished pieces are also improved. The major advantage, however, is that the water facilitates impregnation of the filler with resin—an objective which is greatly desired.[9] Finally, the addition of small amounts of zinc stearate or calcium stearate facilitates removal of the finished piece from the mold, and insures cleanliness of the surface of the latter.

Dyes and pigments in compound. Carbon black is one of the least expensive materials which may serve as a coloring agent. As the natural color of hydrolyzed lignocellulose-phenolic-resin molded pieces is a dark chocolate brown, carbon black is added in small amounts to yield a jet-black molded product of the type used in greatest volume in the molding trade. Lighter brown may be obtained by addition of red dyes and white pigments, while various colors in their darker shades have been obtained either as surface layers, or as homogeneous coloring throughout the molded articles.

Experimental methods

Compounding equipment. Although rubber rolls, modified so that they can be heated internally, have become standing equipment for compounding and compressing the ingredients of molding powders, Banbury mills have been advocated for this service in recent years. These, by the use of heavy paddles of the type used in dough mixers, accomplish the mixing and compressive actions in a steam-heated chamber. Preliminary tests on a Banbury unit indicated that it was difficult to control the compounding of phenolic resins with lignocellulose from the continuous hydrolysis process, since excessive degradation of the fibers of the lignocellulose took place. Rubber rolls are still the most widely used equipment for compounding, and their use would be desirable in this work. Consequently all compounding research was carried out with the use of a standard set of 6-in. × 12-in. chrome-plated rubber rolls equipped for internal heating and cooling, with adjustable nip and a fixed ratio of roll speeds. The ingredients for a given compound, however, were given a preliminary mixing for 15 min. in an open, power-driven planetary mixer, without application of heat or pressure, in

***2**—Grinding equipment for hydrolyzed lignocellulose.* ***3**—Shaking screens for hydrolyzed lignocellulose particle size separation.* ***4**—Compounding rolls for hydrolyzed lignocellulose-phenolic resin molding powders.* ***5**—Molding press and bench used in experimental work*

order to facilitate rapid and uniform compounding on the roll (See Fig. 4).

Since no mechanical controls have ever been devised, the compounding of molding powders is always a matter of visual control and depends entirely upon the operator's skill and judgment. The control of the rolling operation does depend, however, on: (a) the appearance of the sheet during rolling; (b) the manner in which the sheet comes off the rolls; (c) its stiffness, cohesion, surface finish and other similar properties after cooling—all of which vary for each of the individual compounds used in a given branch of the plastics industry.

It is known, furthermore, that the rate of cooling and the method of conditioning of the rolled sheet will have an influence on the molding characteristics of the compound and the physical characteristics of the molded article. The next operation, the grinding of the rolled sheet, plays a greater role than is commonly realized in the final molding operations. Inclusion of excessive amounts of large particles may result in incomplete fusion, causing poor flow and marred surfaces in the molded piece. At the other extreme, however, excessive fines may cause pre-cure due to the large surface available for heat transfer. This pre-cure results in the formation of a hardened shell which limits fusion and cohesion of the larger particles, also reducing flow and marring surface appearance.

Standards for molding and testing. The greatest hindrance to research in the field of plastics is the absence of commonly accepted standards against which to compare results. This does not indicate any lack of effort on the part of workers in this field, but may be blamed upon the varying nature of the materials encountered. A test standardized for one type of molding compound may not yield a fair evaluation of another type of compound. For example, a plasticity test described by Burns[4] yields no results of value when applied to long-fiber-filled molding compounds where separation of resin and filler in the mold is possible. At this time this research program was started, it was decided, therefore, to set up arbitrary standards for the particular type of material involved. These had to be modified from time to time to allow for progressive improvements in the molding compounds obtained from hydrolyzed lignocellulose. Recently, several standard tests for plastics have been proposed by the A.S.T.M.;[1, 2, 7] and although there are some conditions which vary from those of the empirical tests later described, it was found inadvisable to change over in the middle of the program, due to the difficulties involved in correlating test data obtained on the arbitrary standards with the work of others.

The same problem holds in the choice of equipment, even for molds used to produce bars for strength and moisture tests, and for flow tests. Equipment described later was of original design and construction for the greatest part, but is similar to standard equipment now available. It is obvious, however, that the results obtained will not be directly comparable to the published data of other workers. In order to overcome this difficulty, standard molding powders have been tested from time to time in these units, and data so obtained have permitted some correlation with published data.

Another factor which enters into molding, testing and evaluation of results is the conditioning (preheating and adjustment of moisture content) of molding powders prior to use, and of molded pieces prior to testing.[3, 8] The combination of variables involved in this conditioning is of such

6

7

6—Flow test mold. 7—Mold used for forming three 5 in. by 1/2 in. by 1/2 in. test bars simultaneously

importance that this operation has even become a recognized factor of major importance in commercial molding practice, as well as in more precise work of a research nature.

Flow test. Flow was evaluated by use of a positive mold which formed a disk $1^1/_8$ in. in diameter (1 sq. in. effective area). The plunger of the mold had a hole $^1/_8$ in. in diameter and 3 in. (77 mm.) long drilled vertically through its center (Fig. 6). The flow was indicated by the length of the molded stem which formed in the hole. It was recognized, however, that variations in the rate of cure of the molding compounds involved affected this test, as rapid heat transfer to the molded stem would tend to set it up before maximum possible flow was attained.[5] For the greatest part, these tests were made at 325° F. for a period of 4 min. without gassing, under a pressure of 4000 p.s.i., except for later reductions to 2000 p.s.i. for higher-flow molding compounds.

Strength and moisture absorption tests. All test bars for strength and moisture-absorption evaluations were molded in a triple-cavity step mold of the positive type, forming three 5-in. × $^1/_2$-in. × $^1/_2$-in. bars at a time (Fig. 7). Molding was carried on for 4 min. to insure complete cure, at 325°

8—*Testing machine for flexural strength and elasticity*

F., under a pressure of 4000 p.s.i. The mold was gassed by releasing the pressure 20 sec. after closing the mold for a period of 20 seconds. Bars were discharged without cooling the mold. The test bars were placed in an oven at 50° C. for 48 hrs. for purposes of stabilization.[2] After the conditioning period, the bars were placed in a desiccator and permitted to cool to room temperature in an anhydrous atmosphere.

The bars were then submitted to a transverse breaking test in a machine designed according to A.S.T.M. standards,[1] with continuous application of the load by means of a stream of lead shot (Fig. 8). This unit was equipped with a deflection gage which also measured the bending of the bar during loading, so that the modulus of elasticity could be calculated from the data taken during this transverse breaking test.

The two halves of the test bar remaining after the transverse breaking test were immediately given an impact test. The machine built for this purpose was essentially a pendulum-type unit, and is shown in Fig. 9. Corrections were made after each test for wind and friction losses. It should be noted that this test was run with the bar clamped vertically (Izod method) but the bar was not notched.

The ends of the test bars left in the clamp after the impact test were weighed and immersed in water at 25° C., the increment in weight being noted at the end of 1 day and at the end of 10 days' immersion. Although the total area exposed to moisture was small, one end of the piece was a broken section which had no protective molded surface; thus, the moisture test was a stringent one.

Calculation of observed testing data. Proceeding from micrometer measurements of the width and depth of the test bars at the breaking points in both transverse and impact tests, the data were calculated on the basis of standard formulae used for these tests. Both the transverse strength and modulus of elasticity are reported in pounds per square inch, while the impact strength is given in foot-pounds per square inch of un-notched bar. There is some disagreement as to methods of reporting the last value, some workers giving results in terms of foot-pounds required to break the $^1/_2$-in. × $^1/_2$-in. bar (this method appears unreliable as it is difficult to ensure that the depth of the bar will always be $^1/_2$-in.) while others using a notched bar give test data in terms of foot-pounds per inch of notch.

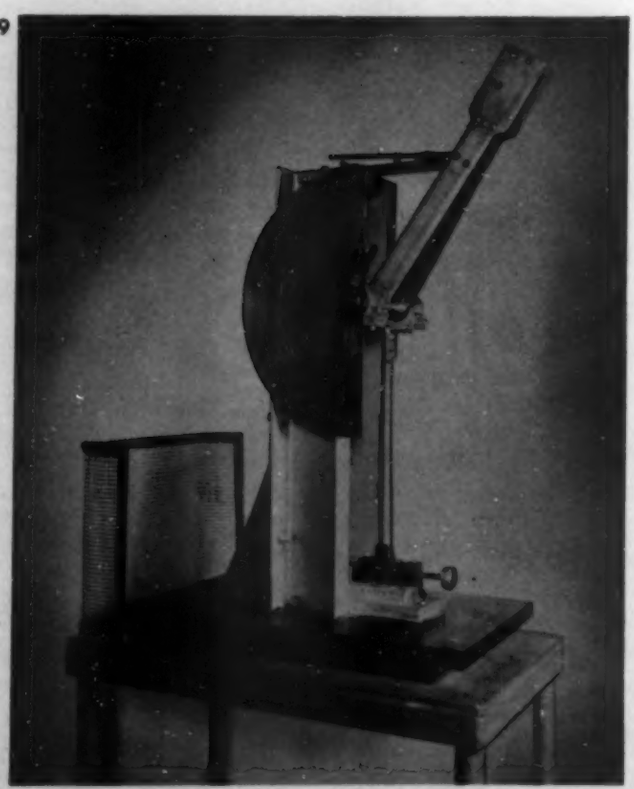
Flow test data are reported as the length (in millimeters) of the molded stem which forms in the test mold under standard conditions of pressure, temperature and time. This is only a relative value and has only a qualitative relationship to other flow tests. In any case, it should be kept in mind that a flow test so obtained is not necessarily an accurate measure of the molding compound in a commercial holding operation, due to differences in the cure factor.

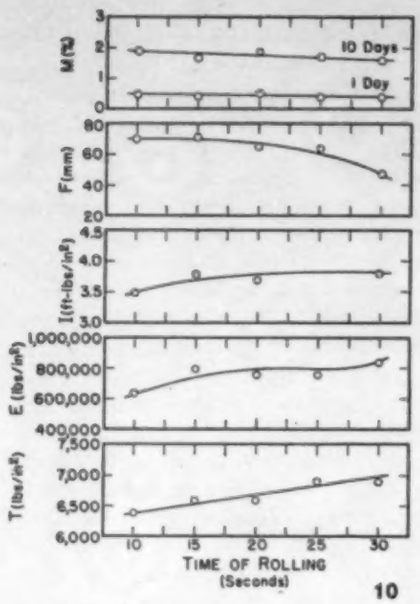
All data are presented with only two significant figures, as the reproducibility of the samples themselves in molding work does not warrant greater precision.

Lignocellulose compounding variables

In order to minimize variables, all of the experimental work (except where noted) was carried out with a standard resin, BR-1922, manufactured by the Bakelite Co. Although this resin may not be the best available for this application, it is of a type which lends itself satisfactorily to compounding and molding operations with hydrolyzed lignocellulose fillers. A standard lignocellulose (determined from previous experimentation) was used, and no variation was made in the chemical constitution of this product. Many tests have been made, and those reported here were in series taken to

9—*Testing machine for impact strength*





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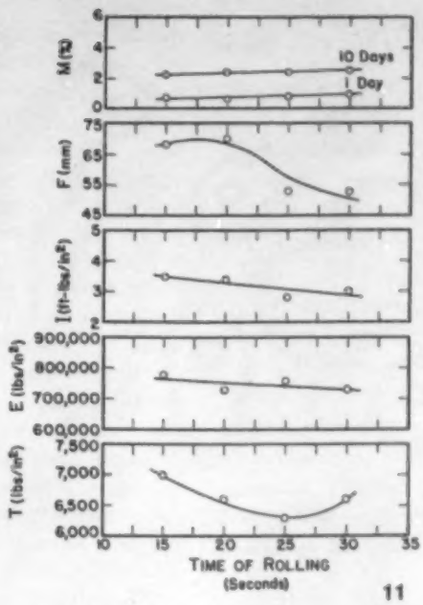

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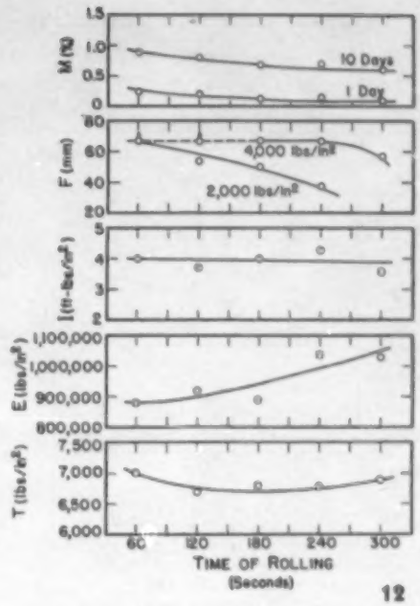

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10–15—***Effect on transverse strength (T), modulus of elasticity (E), impact strength (I), flow (F), moisture absorption (M) of the following factors:*** **10**—***time of rolling for molding compounds containing 75 percent hydrolyzed lignocellulose, 25 percent resin BR-1922.*** **11**—***time of rolling for molding compounds containing 75 percent hydrolyzed lignocellulose, 25 percent resin BR-1922, 3 percent hexamethylenetetramine (based on resin).*** **12**—***time of rolling for molding compounds containing 55 percent hydrolyzed lignocellulose, 45 percent resin.*** **13**—***particle size of hydrolyzed lignocellulose at 15 sec. rolling time for molding compounds containing 75 percent hydrolyzed lignocellulose, 25 percent resin.*** **14**—***particle size of hydrolyzed lignocellulose at 20 sec. rolling time for molding compounds containing 75 percent hydrolyzed lignocellulose, 25 percent resin.*** **15**—***particle size hydrolyzed lignocellulose at 25 sec. rolling time for molding compounds containing 75 percent hydrolyzed lignocellulose, 25 percent resin***

show the effects of specific variables in the compounding operation. The appended table lists the experimental data.

Time of rolling—catalyst and resin content. Mixtures were made of 1 part resin to 3 parts lignocellulose. In addition, there were added: 10 percent water, based on the lignocellulose, 2 percent carbon black, plus $^1/_2$ percent zinc stearate, based on the total of resin and lignocellulose. Figure 6 shows the variation in physical properties for this compound with increase in time of rolling.

Of greatest importance is the fact that transverse strength increases steadily with time of rolling, while flow decreases only slightly up to 25 sec. rolling time, and then drops off rapidly. Impact strength remains fairly constant, while the modulus of elasticity increases, though erratically. Resistance to moisture increases with rolling time, especially in the 10-day test.

Repetition of this experiment with the same compound—except that 3 percent of hexamethylenetetramine (based on the resin) was added to accelerate cure—led to the data in Fig. 11.

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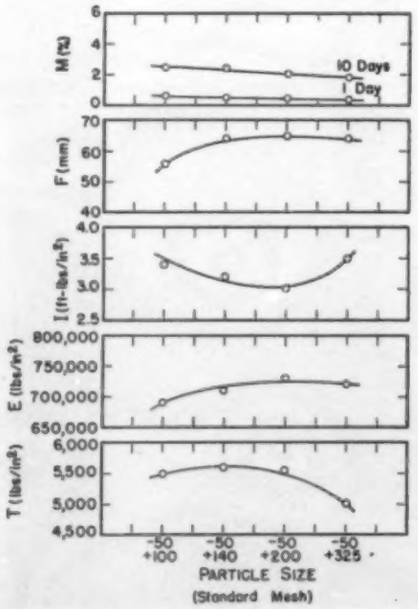

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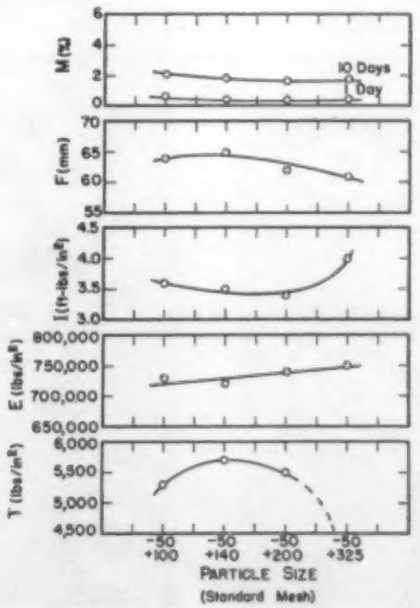

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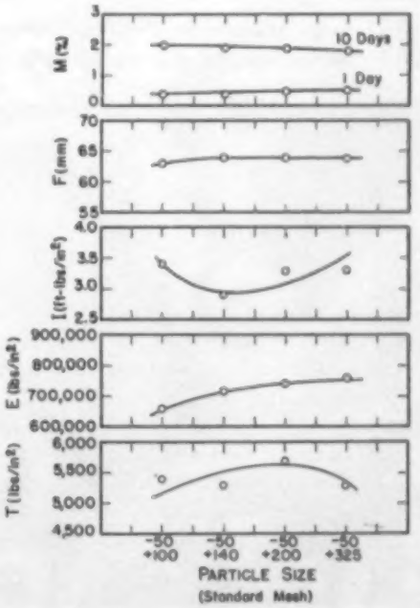

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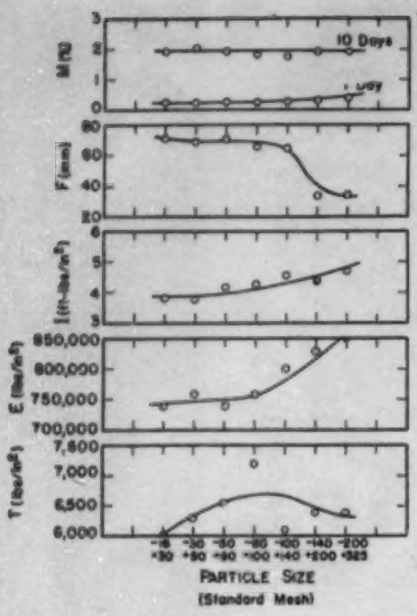

16—Effect on transverse strength (T), modulus of elasticity (E), impact strength (I), flow (F), moisture absorption (M), of particle size of hydrolyzed lignocellulose (differential curves) at 30 sec. rolling time for molding compounds containing 75 percent hydrolyzed lignocellulose, 25 percent resin

Except for flow, the trends are almost reversed. Flow itself drops off more rapidly than in the first case, while transverse strength drops rapidly at first and then increases slightly. Even impact strength decreases somewhat. The only conclusion possible is that additional hexamethylenetetramine (over that contained in the resin) has only deleterious effects on the lignocellulose-filled molding compound. This result has been checked with mixtures containing up to 15 percent of hexamethylenetetramine, based on the resin. It is possible that a compound made with a resin having less hexamethylenetetramine (or none at all) might give even better results.

A third experiment, in which the hexamethylenetetramine was omitted and the resin-to-lignocellulose ratio was changed to 9:11, is shown in Fig. 12. Here the results were similar to those shown in Fig. 10, except that the transverse strength remained almost constant. Two important effects were noted, however. First, it was necessary to keep this compound on the rolls for as long as 4 to 5 min. to obtain sheeting characteristics comparable to those which resulted after only 30 sec. rolling in the first experiment. Secondly, the resistance to moisture absorption was exceptionally good in both the 1-day and 10-day tests, especially after 3 min. rolling time. On the whole, flow did not increase in proportion to resin content, indicating the influence of secondary cure factors. The improved flow which was obtained, however, necessitated repetition of flow tests at 2000 p.s.i. in order to determine the true trend.

Time of rolling—particle size of lignocellulose. Hydrolyzed lignocellulose after grinding may have a wide range of particle sizes. Generally, the fibers must be ground fine enough to permit thorough mixing and impregnation with the resin, and for this reason all the lignocellulose used was ground so as to pass through a standard 50-mesh screen. In order to determine the effect of finer particles, this ground material was passed over 100, 140, 200 and 325-mesh standard screens to remove the corresponding fines. Thus the residual samples through 50-mesh and on finer screen would correspond to the overall particle size range which would be used in practice. Although these lignocellulose fines do not show up as such in the finished molding compound, they affect the formation of similar fine particles during the grinding of the rolled sheet.

Figures 13, 14 and 15 represent data taken on the compound of the first experiment for concurrent variations in time of rolling, and in particle size of lignocellulose after its grinding and before compounding. Although variations in several of the physical properties are so slight as to indicate no appreciable effect caused by the particle size variable, other properties are affected.

Transverse strength for each of the three rolling times shows an optimum for lignocellulose of particle distribution between the values of: *through* 50 *on* 140 mesh to *through* 50 *on* 200 mesh. This is, however, a very abrupt decrease when fines of particle distribution: *through* 200 *on* 325 mesh are included in the compound. Modulus of elasticity increases in all cases as finer material is contained in the hydrolyzed lignocellulose. Flow and moisture absorption remain fairly constant with variation in particle size. Impact strength decreases to a minimum where transverse strength is greatest, and increases again when fines are included in the lignocellulose.

17—Assorted parts molded from plastics filled with hydrolyzed lignocellulose.
18—Electrical parts molded from plastics filled with hydrolyzed lignocellulose

17

18

TABLE I.—EXPERIMENTAL RESULTS

Test no.	Particle size (mesh)	Hex (%)	Rolling time (sec.)	T (p.s.i.)	E (p.s.i.)	I (ft.-lb./sq. in.)	F mm. at 4000 p.s.i.	M (%) 1 day	M (%) 10 day	
Time of rolling —25 percent resin (Fig. 10)										
7929	−50 + 100	0	10	6400	640,000	3.5	70	0.5	1.9	
7930	−50 + 100	0	15	6600	800,000	3.8	71	0.4	1.7	
7931	−50 + 100	0	20	6600	760,000	3.7	65	0.5	1.9	
7932	−50 + 100	0	25	6900	760,000		64	0.4	1.7	
7933	−50 + 100	0	30	6900	840,000	3.8	47	0.4	1.6	
Time of rolling—25 percent resin + hex (Fig. 11)										
7846	−50 + 100	3	15	7000	830,000	4.5	68	0.7	2.3	
7847	−50 + 100	3	20	6600	780,000	4.4	70	0.6	2.4	
7848	−50 + 100	3	25	6300	810,000	3.8	53	0.8	2.4	
7849	−50 + 100	3	30	6600	780,000	4.0	53	0.9	2.5	
Time of rolling—45 percent resin (Fig. 12)										
7261	−50 + 100	0	60	7000	830,000	4.0	77+*	0.25	0.9	77
7262	−50 + 100	0	120	6700	870,000	3.7	77+	0.20	0.8	64
7263	−50 + 100	0	180	6800	840,000	4.0	77	0.12	0.7	60
7264	−50 + 100	0	240	6800	990,000	4.3	77	0.15	0.7	47
7265	−50 + 100	0	300	6900	980,000	3.6	67	0.08	0.6	—
										*At 2000 p.s.i.
Lignocellulose particle size—15-second rolling (Fig. 13)										
8037	−50 + 100	0	15	5500	690,000	3.4	56	0.6	2.2	
8040	−50 + 140	0	15	5700	710,000	3.2	64	0.5	2.2	
8043	−50 + 200	0	15	5600	730,000	3.0	65	0.4	3.0	
8046	−50 + 325	0	15	5000	720,000	3.5	64	0.4	1.9	
Lignocellulose particle size—20-second rolling (Fig. 14)										
8038	−50 + 100	0	20	5300	730,000	3.6	64	0.6	2.1	
8041	−50 + 140	0	20	5700	720,000	3.5	65	0.4	1.9	
8044	−50 + 200	0	20	5500	740,000	3.4	62	0.4	1.7	
8047	−50 + 325	0	20	3800	750,000	4.0	61	0.4	1.8	
Lignocellulose particle size—25-second rolling (Fig. 15)										
8039	−50 + 100	0	25	5400	660,000	3.4	63	0.4	2.0	
8042	−50 + 140	0	25	5300	720,000	2.9	64	0.4	1.9	
8045	−50 + 200	0	25	5700	740,000	3.3	64	0.5	1.9	
8048	−50 + 325	0	25	5300	760,000	3.3	64	0.5	1.8	
Lingocellulose particle size—differential (Fig. 16)										
7464	−16 + 30	0	30	6000	740,000	3.8	71	0.20	1.9	
7465	−30 + 50	0	30	6300	760,000	3.8	69	0.20	2.1	
7466	−50 + 80	0	30	6600	740,000	4.2	71	0.25	1.9	
7467	−80 + 100	0	30	7200	760,000	4.3	66	0.25	1.8	
7468	−100 + 140	0	30	6100	800,000	4.6	65	0.25	1.7	
7535	−140 + 200	0	30	6400	830,000	4.4	34	0.35	1.9	
7537	−200 + 325	0	30	6400	850,000	4.7	35	0.40	1.9	

T-transverse strength; *E*-modulus of elasticity; *I*-impact strength; *F*-flow; *M*-moisture absorption.

Cross comparisons indicate that the effect of time of rolling in these three series was negligible when compared with the effect of particle size variation.

As the particle size points plotted in the three foregoing graphs may be considered as integrals of particle size variation, another plot showing the differential variation of particle size would be desirable. For this purpose, lignocellulose samples were passed over a series of consecutive standard screens and a series of samples was obtained of progressively decreasing particle size. In Fig. 16, the stepwise fractionation of hydrolyzed lignocellulose powder on a series of screens magnifies the effect of particle size on physical characteristics of the lignocellulose molding compound. There is an optimum for transverse strength in sizes approximating 80 to 100 mesh (although wide variations in data at this point indicate a critical state of division); while modulus of elasticity and impact strength increase with increased state of division. Flow, however, decreases considerably for particle sizes smaller than 140 mesh, while moisture absorption remains more or less constant.

Combining optimum variables. By proper combination of optimum values of the variables described above, compounds giving molded samples having greatly improved properties are obtained. For example, a compound now in use containing 1 part of resin BR-1922 to 3 parts of continuously hydrolyzed lignocellulose has a transverse strength of 7600 p.s.i., impact strength of 4.1 ft.-lb./sq. in. and flow of 77 mm.

Substitution in the same ratio of another phenol-formaldehyde resin for the BR-1922, however, has resulted in considerable improvement, as shown by a tranverse strength of 8500 p.s.i. and an impact strength of 4.3 ft.-lb./sq. in., other properties remaining the same as above. It is probable that other resins, particularly if formulated especially for this use, might show even better results.

Although many experiments have been carried out to try to evaluate the cure factor, the only conclusion obtainable is that cure tests in the laboratory have little or no relation to the cure time of a molded object in a production mold. Variables such as the type of (*Please turn to page 122*)

American Chemical Society meeting

THE following are abstracts of papers presented at the meeting of the Division of Paint, Varnish and Plastics Chemistry of the American Chemical Society held in Buffalo, New York, September 7–11, 1942. Dr. S. L. Bass is chairman of the Division, and Dr. A. C. Elm is secretary.

CREEP PHENOMENA IN FILAMENTOUS MATERIALS AND OTHER HIGH POLYMERS. Herbert Leaderman, The Textile Foundation, M.I.T., Cambridge, Mass.

Time effects play an important part in the mechanical behavior of plastics and textile fibers at room temperature. In many cases these time effects are due mainly to the existence of a delayed elasticity superimposed upon Hooke's law or instantaneous elasticity, the delayed component of the deformation being a function of the previous loading history. Methods are discussed of investigating the delayed elastic behavior in the light of Boltzmann's superposition principle. It is shown that this principle is obeyed by plasticized polyvinyl chloride specimens under small deformations. For more highly plasticized rubberlike materials and for highly oriented filamentous materials the delayed elastic behavior is described by modifications of the principle. The delayed elastic behavior of nylon under large loads does not obey the superposition principle.

THE THERMODYNAMIC PROPERTIES OF HIGH POLYMER SOLUTIONS. I. OSMOTIC PRESSURE. T. Alfrey, A. Bartovics and H. Mark, Brooklyn Polytechnic Institute, Brooklyn, N. Y.

The osmotic pressure-concentration curve was determined for a number of polystyrene samples, with toluene as the solvent. The osmotic molecular weight and the limiting intrinsic viscosity were used in each case to calculate the appropriate Km constant for the polystyrene. Polystyrene prepared at 60°, 120° and 180° C. was fractionated by solvent-nonsolvent precipitation. The fractions so obtained were investigated in the above manner. It was found that the polystyrene samples obtained from high-temperature polymerization possessed lower Km constants than those obtained in low-temperature polymerization. This is interpreted as evidence of chain branching during high-temperature polymerization.

THE THERMODYNAMIC PROPERTIES OF HIGH POLYMER SOLUTIONS. II. VAPOR PRESSURE. T. Alfrey, J. Hanson and W. Zybert, Brooklyn Polytechnic Institute, Brooklyn, N. Y.

The vapor pressures of solvent from polystyrene solutions of different composition were measured as a function of temperature. This permitted calculation of the partial molal heat and entropy of solution of the solvent. The large deviations from Raoult's law were found to arise from additional entropy gains on going into solution. The results were compared with the predictions of the Huggins-Flory theory.

MEAUREMENT OF THE HEAT OF POLYMERIZATION OF STYRENE. G. Goldfinger, D. Josefowitz and H. Mark, Brooklyn Polytechnic Institute, Brooklyn, N. Y.

The knowledge of the heat of polymerization is of importance industrially to determine inevitable temperature fluctuations inside of a polymerizing material which result in a nonuniform product. Luschinsky [W. V. Luschinsky, Z. Physik. Chem. *A183*, 384 (1938)] determined the heats of combustion of monomer and polystyrene and computed the heat of polymerization from these data by difference. This difference is relatively small (about 1.5 per cent of total heat of combusion). This naturally limits the accuracy of the method. It was therefore attempted to make direct measurements of the heat effect during the polymerization. Two methods were considered:

1. The reaction was carried out adiabatically in a Dewar flask, immersed in an oil bath, kept automatically at the same temperature as the reaction vessel, thus minimizing heat losses. The temperature increase was carefully measured and considered proportional to the heat of reaction.

2. The reaction was carried out isothermally in an apparatus somewhat similar to a steam calorimeter. The heat of polymerization caused water to evaporate. By measuring the amount evaporated, the heat of reaction could be determined. This method met with considerable experimental difficulties. The value of H found by method (1) was 16,000 ± 500 cal. per mole of styrene polymerized. The method promises to yield better accuracy after some improvements have been made, and should enable us to determine the heat of reaction as a function of the degree of polymerization.

THE VISCOSITY OF DILUTE SOLUTIONS OF LONG-CHAIN MOLECULES. DEPENDENCE ON THE SOLVENT. Maurice L. Huggins, Eastman Kodak Company, Rochester, N. Y.

Staudinger's relation between η_{sp}/c and the molecular weight of a chain molecule solute should apply only if the chains are kinked in a purely random way. Actually they are more or less tightly coiled than this, depending primarily on whether the average cohesive energy density between like units (solvent molecules and solute submolecules) is greater or less than that between unlike units. The tighter the coiling, the less the specific viscosity, other things being equal. This cohesive energy density difference is closely related to μ_1, a constant entering into equations recently derived by the author for the activities of the components and for related properties such as osmotic pressure, solubility, and precipitability. In general, the η_{sp}/c values for solutions of a given polymer in different solvents are symbatic with the proportion of a poor solvent required to produce precipitation of a solid phase.

A STUDY OF THE BODYING OF GLYCERYL TRILINOLEATE WITH ETHYLCELLULOSE. L. L. Carrick and Herbert James Fletcher, North Dakota State College, Fargo, N. D.

The effect of ethylcellulose upon the heat bodying of glyceryl trilinoleate was studied using both the synthetic glyceride and linseed oil. The oils were heated in nitrogen to 295° C. in about 15 minutes and 8 percent of ethylcellulose (100 cps., 2.5 dS) added at 240° C. The progress of the reaction was followed by changes in physical and chemical properties while holding at 295° C. The reaction passes through the following stages:

(1) Rapid solution of the ethylcellulose in the hot oil, forming a clear gel when cold.

(2) Rapid breakdown of the gel to a clear flowable oil whose viscosity rapidly approaches a minimum and which becomes soluble in naphtha. Ethylcellulose is progressively degraded and in the presence of high fatty acid content loses a portion of its ethyl groups.

(3) Gradual build-up of viscosity eventually yielding a gel of bodied oil.

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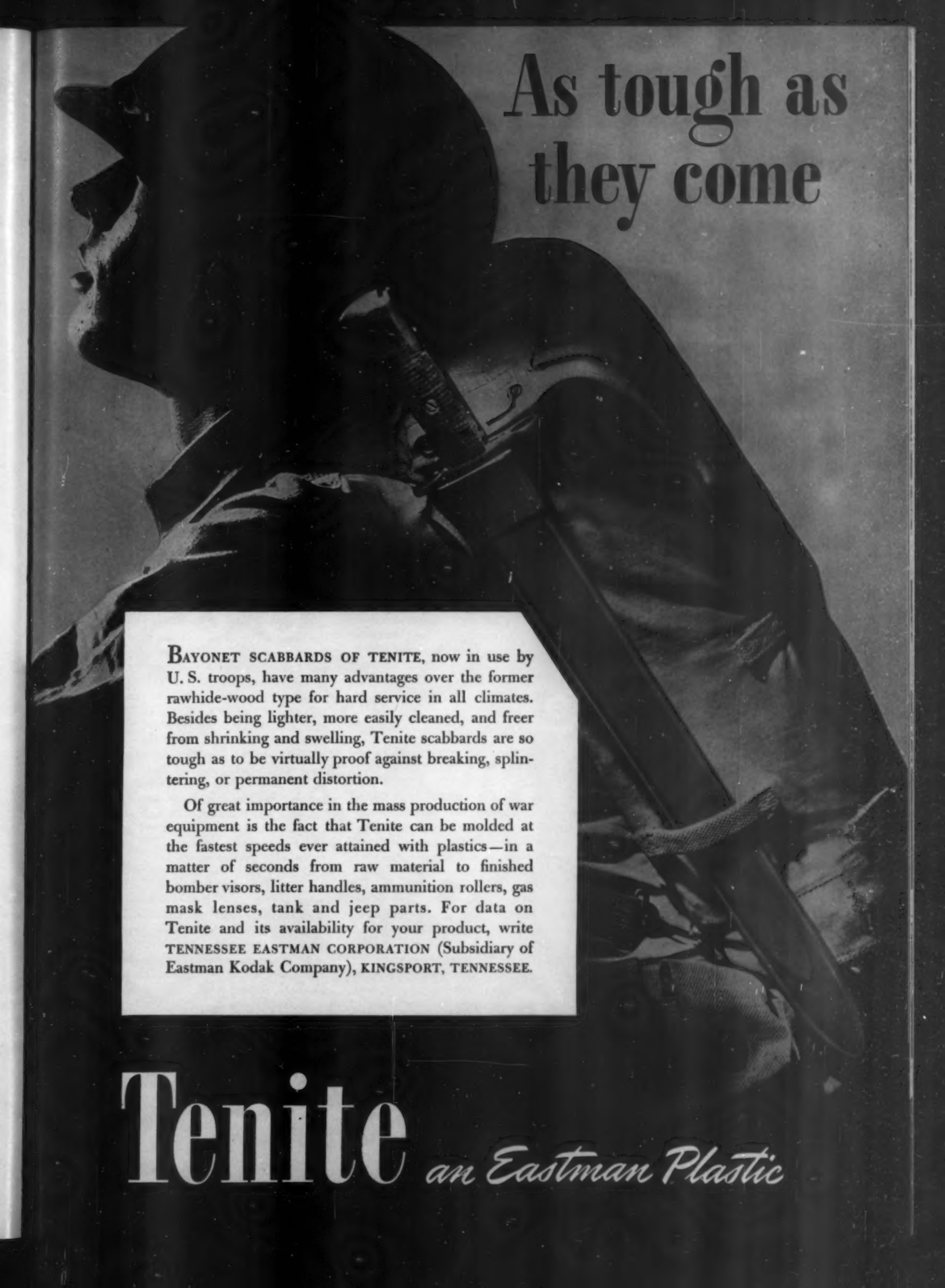

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Technical briefs

Abstracts of articles on plastics in the world's scientific and engineering literature relating to properties and testing methods, or indicating significant trends and developments

Engineering

DUST CONTROL IN THE PLASTICS INDUSTRY. J. W. Merrill and J. E. C. Valentin. Trans. Amer. Inst. Chem. Eng. *38*, 813–30 (Aug. 25, 1942). The sources of dust, hazards resulting from dust and methods for controlling dust in plants producing and using synthetic resins are discussed. A discussion of the factors to be considered in choosing a dust-collecting system is also given.

HEAVY-DUTY BEARINGS IN PLASTICS. Plastics *6*, 253–60 (Aug. 1942). The use of plastics in bearings has been limited by 1) excessive expansion caused by the high thermal coefficient, 2) accumulation of heat caused by the low thermal conductivity and 3) swelling on being subjected to lubricants. A new device is described which utilizes a thin resin-impregnated paper or fabric band molded on the shaft which operates in a steel bearing. Bearings made from paper, linen, asbestos, glass wool and hemp reinforced plastics were tested and the results compared with tests made on some common metal bearings. Plastic bearings were found to be superior to tin alloy and lead alloy bearings, but not to high-grade bearing bronzes. The manufacture, factors controlling production and use, results of laboratory and service tests, and advantages and disadvantages of plastic bearings are discussed.

HIGH-FREQUENCY HEAT USED TO MAKE PLYWOOD. Elec. World *117*, 70, 72 (June 27, 1942). A brief description of two presses utilizing high-frequency current for heating purposes to make resin bonded plywood.

Chemistry

A NEW PRECIPITANT FOR GROUP II IONS. S. Gaddie. J. Chem. Ed. *19*, 327–8 (July 1942). The use of Amberlite IR-4 as a carrier for hydrogen sulfide for use in the precipitation of group II ions as sulfides is described. It is reported that the resin adsorbs 12 percent of its weight of hydrogen sulfide, and that the product has been kept for eight months without decomposition when stored in tightly stoppered flasks or test tubes.

COPOLYMERIZATION OF ALKYL ACRYLATES AND ALKYL MALEATES. SOME KINETIC STUDIES ON COPOLYMERIZATION. C. S. Marvel and R. L. Frank. J. Am. Chem. Soc. *64*, 1675–8 (July 1942). The copolymerization of various mixtures of *l*-monomenthyl maleate and ethyl acrylate in the presence of benzoyl peroxide was studied. It was found that (1) the rate of reaction is independent of the concentration of the acrylate, (2) the rate of reaction is directly proportional to the peroxide concentration, (3) the polymer chains contained less than one moleate unit for each acrylate unit and (4) the reactions were of zero order. The experiments were repeated with *l*-menthyl acrylate and ethyl maleate but the data were such that it was impossible to ascertain whether the reactions were zero order or first order. *l*-Menthyl acrylate alone polymerizes according to first-order kinetics.

MELAMINE FORMALDEHYDE CONDENSATION PRODUCTS. A. Gams, G. Widmer and W. Fisch. Helv. Chim. Acta *24*, 302–19E (1941). Melamine was reacted with various amounts of formaldehyde under various conditions and the resulting resins analyzed for C, H, N and O. The results of the analyses are given to furnish material for a study of the mechanism of the condensation reaction.

Testing

TRANSITION TEMPERATURE AND CUBICAL EXPANSION OF PLASTIC MATERIALS. F. E. Wiley. Ind. Eng. Chem. *34*, 1052–6 (Sept. 1942). A test to measure the "transition temperatures" of plastics and their cubical coefficients of expansion is described, and data obtained by this test are presented. The apparatus is simple and may be readily constructed from standard laboratory equipment. No inordinate skill is required on the part of the laboratory technician in securing precise results by this method. It is shown that changes in the slope of the temperature-expansion curve correspond to the softening points found by several commonly used tests. Data on the temperature limitations of plastics have been obtained which are of value in determining the utility of plastics for industrial use.

EXPERIMENTS ON FOAM TIME. I. THE METHOD OF MEASURING FOAM TIME AND SOME EXPERIMENTS WITH SAPONIN AND METHYL CELLULOSE. F. Schütz. Trans. Faraday Soc. *38*, 85 (Feb.–Mar. 1942). The "foam time" of solutions of three methylcelluloses of different molecular weights was determined in an attempt to establish the relation between molecular weight and foam stability. A definite relation appears to exist but a determination of molecular weight from "foam time" is not possible. The methoxyl content of the first foam fraction is higher than that of the original solution.

PHOTOELASTIC ANALYSIS POINTS TO STRONGER BOLTS. Product Eng. *13*, 476 (Aug. 1942). In order to analyze stresses and strains in big steel bolts, transparent plastic models were made and loaded in the same way they would be in service. The stress lines or fringes were frozen in by annealing. Polarized light was used to study the stress distribution.

Properties

THE STABILITY OF PHENOLIC PLASTICS. II. WATER RESISTANCE. A. D. Sokolov, A. V. Kon and N. S. Zarubina. Plasticheskie Massy, Sbornik Statei *1939*, 141–5. Imported samples of phenolic resins reached their limit of swelling in water after 15 to 24 months' immersion. The weight increased from 5 to 8.5 percent and elongation increased from 1 to 2 percent. III. BEHAVIOR AT VARIOUS HUMIDITIES. A. D. Sokolov and N. S. Zarubina. *Ibid.*, 153–67. Immersion in water caused faster swelling than exposure to moist air, but the limit was approximately the same in both cases. For humidities 0 to 80 percent, the maximum swelling was equal to $0.0571 \times (W - 38.6)$, where W is the relative humidity. The surface resistance in moisture-saturated air was 10^9 ohms and in dry air 10^{14} to 10^{13} ohms. IV. CHEMICAL RESISTANCE. A. D. Sokolov and N. S. Zarubina. *Ibid.*, 167–83. The resistance of resins, prepared from mixtures of formaldehyde and phenol or cresol of various molal ratios, to 50 percent sulfuric acid, hydrochloric acid (sp. gr. 1.19), 10 percent sodium carbonate, 5 percent sodium hydroxide ethyl alcohol and water was determined. The phenol resins were more resistant to acids than the cresol resins, whereas the opposite was true for water and sodium carbonate solution. Resins made from mixtures with excess formaldehyde and those cured with 20 percent "hexa" had maximum resistance to alkali and alcohol. The ratio of the components had no effect on the resistance of the cresol resites to alcohol. Resites were more resistant to acids than novolacs.

PROPERTIES OF SYNTHETIC RESIN TREATED WOODS. F. J. Grush. Product Eng. *13*, 414 (July 1942). The penetration of untreated and phenolic resin impregnated Oregon pine and balsa wood by a $\frac{1}{2}$-in. steel ball was measured. The results show that the impregnation with phenolic resin increased the hardness of the wood surfaces.

AN IMPORTANT STATEMENT TO THE PLASTICS INDUSTRY BY THE PIONEER PRODUCER OF POLYSTYRENE

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PLASTICS

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PRODUCTS OF CHEMICAL PROGRESS

Plastics digest

This digest includes each month the more important articles of interest to those who make or use plastics. Mail request for periodicals mentioned directly to individual publishers

General

THE FUTURE OF THE PLASTICS INDUSTRY. R. P. Chew. Chem. Ind. *51*, 214–19 (Aug. 1942). The future of the plastics industry during and after the war is predicted on the present status of industrial production and developments now underway. It is pointed out that the war will cause an acceleration in development of new ideas and items which under normal conditions would require years to get on the production line. The industry can be expected to grow after the war and may become equal in size to many of our principal manufacturing industries. The economic factors limiting the use of plastics, particularly in competition with metals, are discussed.

ADVANCES IN PRODUCTION AND ASSEMBLY OF PLYWOOD IN AIRCRAFT CONSTRUCTION. H. G. Bersie and E. R. Clarke. Aero. Eng. Rev. *1*, 13–9 (July 1942). A review of the important changes that have occurred in the manufacture of aircraft veneer and aircraft plywood since the last World War. The topics considered are log selection, cutting, drying, testing, bonding, specific gravity, humidity control, clipping, edge jointing, edge gluing, specifications, hot pressing, plywood design, factory tooling, fixtures, protective finishes and production expansion. It is pointed out that the merits of plywood cannot be fully appreciated if an aircraft plant is tooled up solely to produce metal airplanes. To be given a fair trial, wood should be used throughout a good portion of the airplane.

USE OF PLASTICS AND ALLIED MATERIALS IN AIRCRAFT CONSTRUCTION. G. W. De Bell. J. Aeronautical Sci. *9*, 341–9 (July 1942). A review of plastics used in aircraft construction. The design considerations affecting utilization and the various aircraft factors, such as temperature, impact strength and weight requirements, affecting design are discussed. Plastics, classified as thermosetting, thermoplastic and wood veneer materials for purposes of discussion, are examined from the viewpoint of resistance to wear, coefficient of expansion, water absorption, relative cost, limitations, tolerances and availability.

CHEMICAL UTILIZATION OF WOOD WASTE. R. S. Aries. Chem. Ind. *51*, 191–7 (Aug. 1942). The possibilities of utilizing wood waste as fuel, to obtain chemicals by distillation, to make pulp and paper products, to produce sugars, alcohol, plastics, fillers for plastics, and motor fuels, and as an ingredient in composition products are discussed from the viewpoint of what has been done and where this research is leading us.

Materials

PREPARATION OF COPOLYMERS OF STYRENE AND METHYL ISOPROPENYL KETONE. B. N. Rutovskiĭ and G. S. Goncharov. J. Applied Chem. (U.S.S.R.) *14*, 542–50 (1941). The preparation of methyl isopropenyl ketone is described. The copolymerization of this material with styrene under various conditions and in the presence of 0.5 percent benzoyl peroxide was studied over a wide range of mixtures with and without solvents. Maximum viscosity materials were obtained from mixtures containing 10 percent and 70 percent of the ketone when no solvents were used. In 80 percent ethanol solutions, true copolymerization occurred in mixtures with less than 50 percent ketone. Copolymers containing 10 and 25 percent of the ketone had higher impact resistance than polystyrene.

PLASTIC MASSES FROM CONDENSATION PRODUCTS OF PHENOL WITH BUTYRALDEHYDE. S. N. Ushakov and E. N. Freidberg. Plasticheskie Massy, Sbornik Statei *1939*, 203–14. Condensation of butyraldehyde with phenol in acid medium yielded products of low viscosity. These materials were slow curing and the molding powders were very fluid. The addition of formaldehyde helped only if added in a multistage process. The products had satisfactory mechanical properties but were poor in heat resistance.

HEAT-STABLE PLASTICS. Chem. Trade Journal and Chem. Eng. *110*, 371–2 (Apr. 10, 1942). Polymers of methyl silicon and related compounds in which methyl groups are replaced in part by oxygen are described. These condensation products, referred to as heat-resisting silicon plastics, have no carbon to carbon bonds. They are prepared by hydrolyzing a methyl silicon halide and condensing the resulting hydroxy product above the hydrolysis temperature. A typical product has a density of 1.19 g./cc., contains 1.41 methyl groups per silicon atom, is insoluble in water, ethyl alcohol and glycol, is soluble in ether, is difficult to ignite and burns slowly leaving a white ash, can be heated at 200° C. in air for several days without apparent changes other than some embrittlement, oxidizes in air at 300° C. can be heated in a vacuum at 550° C. for 20 hrs. with no effect other than yellowing, is clear, is colorless, has dielectric constants of 3.7 at 26° C. and 3.6 at 56° C., and has power factors of 0.008 at 26° C. and 0.0045 at 56° C. for 60 cycle current. It is suggested that this new type of plastic may be used for electrical insulation and where heat-resistant materials are needed.

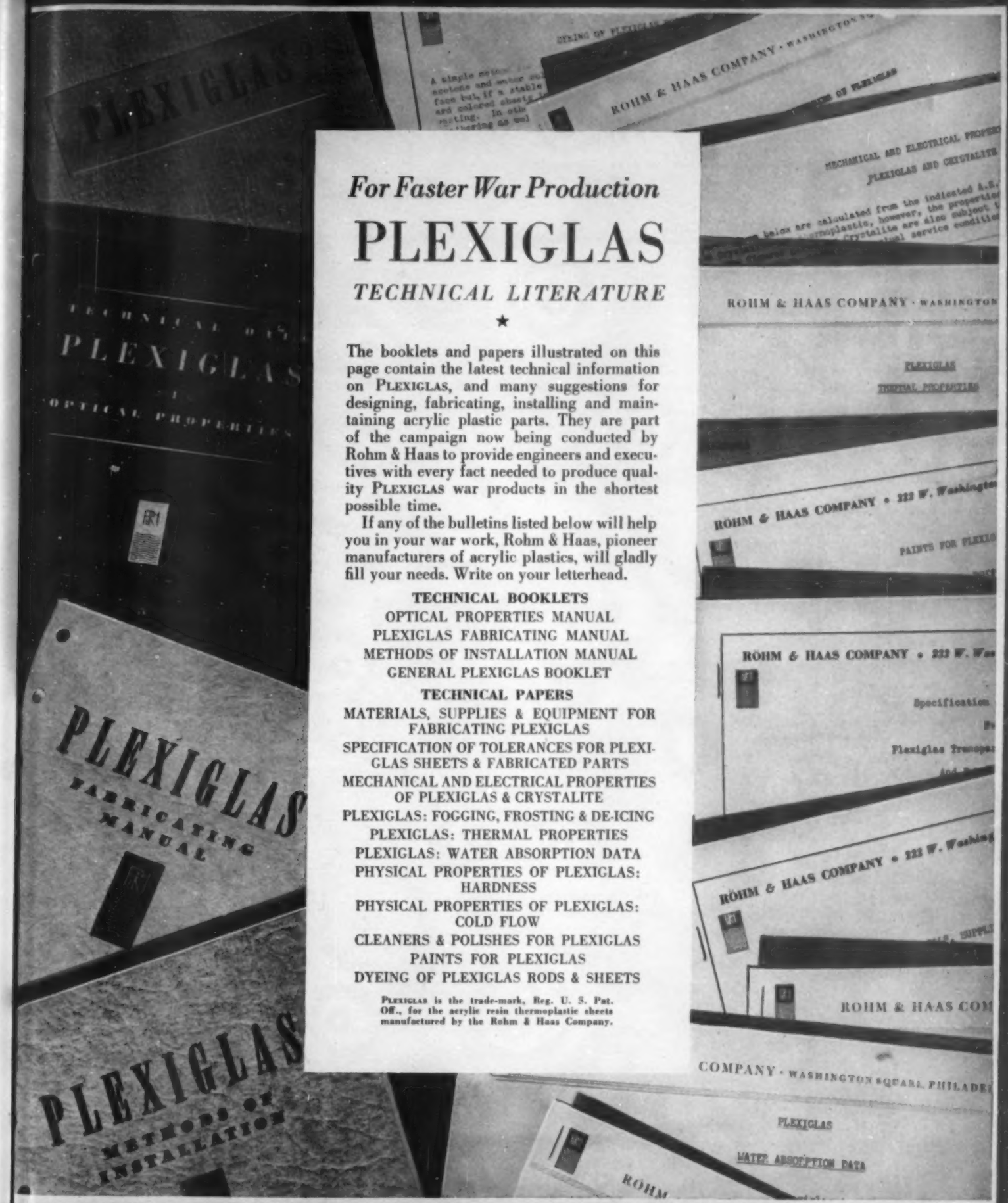
SOY MEAL IN PLASTICS. L. L. McKinney. Soybean Digest *2*, No. 8 4–5, 11 (1942). A plastic composition consisting of 20 percent treated soybean meal, 40 percent phenol-formaldehyde resin, and 40 percent woodflour compares favorably with one consisting of 50 percent phenol-formaldehyde resin and 50 percent woodflour. The treated soybean meal is prepared by washing the meal free of soluble materials with water at the isoelectric point (pH 4.1–4.3), raising the water content to 20 percent, heating under pressure at 225–250° F. for 2–3 hrs., and releasing the pressure suddenly. The water escapes, leaving a dry product suitable for combining in molding powders.

Applications

SYNTHETIC RESIN REPLACES INDUSTRIAL RUBBER. Chem. and Eng. News *20*, 1003 (Aug. 25, 1942). The use of Resistoflex, polyvinyl alcohol, as a substitute for rubber by the RCA Mfg. Co. is discussed. Resistoflex has been used successfully by this company to replace rubber in flexible gas lines, washers, spacers, rollers, power transmission rings, sandblast lines and shields, conveyor belts, shock absorbers, gaskets, vibration dampers, etc.

THE USE OF GLUE IN WOODEN AIRCRAFT. J. G. MacDermot. Aero Digest *41*, 186, 267–70 (July 1942). The wooden plane may become more important during the war because of scarcity of aluminum and afterward because of the advantageous characteristics, low cost and easy workability of wood. This is going to mean that the use of glue in aircraft will become at least equally important. The only new development in the current plywood airplane is in the synthetic resin adhesive used to join the veneers. The properties of casein and resinous glues are reviewed.

IMPREGNATED PLYWOOD BECOMES WAR MATERIAL. J. Delmonte. Mach. Design *14*, 53–7 (July 1942). Data on the hardness, tensile strength, modulus of elasticity, water absorption, swelling and general physical properties of phenolic-resin-impregnated plywoods are given. These materials have several advantages over wood, probably the most important of which is dimensional stability.



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TECHNICAL LITERATURE

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PLEXIGLAS FABRICATING MANUAL
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SPECIFICATION OF TOLERANCES FOR PLEXIGLAS SHEETS & FABRICATED PARTS
MECHANICAL AND ELECTRICAL PROPERTIES OF PLEXIGLAS & CRYSTALITE
PLEXIGLAS: FOGGING, FROSTING & DE-ICING
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U. S. Plastics Patents

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PHENOL-ACID RESIN. A. D. Macallum (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,290,649, July 21. Condensing monohydric or polyhydric phenols with an aliphatic acid having a triple bond.

AMIDE RESINS. G. F. D'Alelio (to General Electric Co.). U. S. 2,290,674–5, July 21. Condensing an aliphatic aldehyde with maleic diamide or other amides of unsaturated dicarboxylic acids.

POLYETHENE. A. M. Alvarado and G. L. Dorough (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,290,794, July 21. Forming an aqueous dispersion of a solid ethene polymer in presence of a dispersing agent and a protective colloid.

PLASTICIZER. R. L. Campbell (to Harvel Corp.). U. S. 2,290,861, July 28. Adding an alkyl ether of polymerized cashew nut shell oil to a cellulose ether to form a tough, flexible thermoplastic.

ABRASION-RESISTING COATING. W. H. Butler (to Bakelite Corp.). U. S. 2,290,905, July 28. Coating metals with a roughened film of an oleoresin paint in which the resin is an oil-soluble phenol-aldehyde condensation product.

MOLDING LENSES. C. V. Smith (to Univis Lens Co.). U. S. 2,290,917, July 28. A forming die for molding lenses from plastics, and a method of aligning the die parts in a molding press.

ADHESIVE. Wm. C. Dearing and Kenneth D. Meiser. U. S. 2,290,946, July 28. An adhesive in nonlumping powder form contains a water-soluble urea-aldehyde condensation product, cellulosic filler and tricalcium phosphate.

TREATED PAPER. R. P. Hofferbert (to American Cyanamid Co.). U. S. 2,291,079–80, July 28. Increasing the wet strength of paper by treatment with a resinous melamine-formaldehyde or aminotriazine-aldehyde condensation product.

NITROCELLULOSE. G. E. Moos (to American Oak Leather Co.). U. S. 2,291,169, July 28. Nitrating spent tanbark or other woody material from which tannin has been extracted.

RUBBER: FIBER BOND. C. F. Brown and A. E. Brooks (to U. S. Rubber Co.). U. S. 2,291,208, July 28. Bonding rubber to fibers with the aid of a phenol-aldehyde resin and carbon black.

ANTIOXIDANT FOR OILS. M. A. Dietrich (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,291,214, July 28. Stabilizing high viscosity hydrocarbon oils against oxidation by adding a film-forming basic amine resin which is insoluble in oils, water and dilute alkalies.

COSMETIC JAR. G. F. D'Alelio (to General Electric Co.). U. S. 2,291,379, July 28. Lining cosmetic cream jars with a layer of insoluble infusible aminotriazine-aldehyde resin.

RESINIFICATION. W. J. Sparks and D. C. Field (to Standard Oil Development Co.). U. S. 2,291,415–6, July 28. Interpolymerization and condensation of benzyl chloride or the like with unsaturates of the styrene or butadiene types in presence of aluminum chloride.

MOLDINGS FROM WOOD. R. S. Hatch (to General Timber Service, Inc.). U. S. 2,291,432–3, July 28. Compounding a primary amine or an alcohol of the aliphatic, furan, cycloalkyl or aralkyl series with woodflour to form molding compositions.

TENNIS RACKETS. Alexis D. Andreef. U. S. 2,291,440, July 28. A machine for molding the frame, throat and handle portions of tennis rackets from strips of molding composition.

LUBRICATOR. E. S. Miller (to Pure Oil Co.). U. S. 2,291,483, July 28. Threading yarn wicks through a synthetic cellulosic sponge for use as a lubricator.

FOUNDATION MEMBER. Daniel Ganz and Irving Kaplan. U. S. 2,291,545, July 28. Forming plastic units on the front of a porous textile sheet, and plastic anchoring units on the back.

CHLORINATED POLYMERS. A. H. Gleason and R. Rosen (to Jasco, Inc.). U. S. 2,291,574, July 28. Chlorinating olefin polymer resins in solution in a mobile solvent which is inert to chlorine.

MOLDED LENS. E. D. Tillyer (to American Optical Co.). U. S. 2,291,663, Aug. 4. Forming plastic synthetic resin lens blanks from a molding composition which is hard enough to be ground and polished like glass.

COATING WIRE. R. M. Wiley and A. J. Dubord (to Dow Chemical Co.). U. S. 2,291,670, Aug. 4. Continuously extruding a thermally softened insulating polymer onto a wire and drawing the coated wire with its cooled sheath through a constricting orifice.

PRINTING FORMS. F. Albers and E. Schloemann (to General Aniline and Film Corp.). U. S. 2,291,673, Aug. 4. Lacquering a paper base on both sides, facing one side with baryta and then with hardenable gelatin and coating the gelatin with a soft resin film.

VINYL ACETAL PLASTICS. H. L. Cox and J. D. Matlack (to Carbide and Carbon Chemicals Corp.). U. S. 2,291,697, Aug. 4. Making clear homogeneous plastics from solutions of partially acetalized vinyl resins in water-miscible solvents.

TALL OIL RESIN. Isador Miller. U. S. 2,291,824, Aug. 4. Selectively esterifying the fatty components of tall oil and separating the resulting resin-ester-acid complex from the solvent.

MELAMINE RESINS. R. C. Swain and P. Adams (to American Cyanamid Co.). U. S. 2,291,843–4–5, Aug. 4. Compounding alkylated melamine-formaldehyde resins with ester gum or East India resin to make varnish resins.

SYNTHETIC YARN. M. M. Brubaker (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,291,873, Aug. 4. A process for drawing synthetic linear polymer filaments through a die.

JOINING STRIPS. Chas. Emmey. U. S. 2,291,955, Aug. 4. Applying a hot thermoplastic strip to a non-thermoplastic strip on a machine which directs the two strips into contact with each other. *(Please turn to page 106)*

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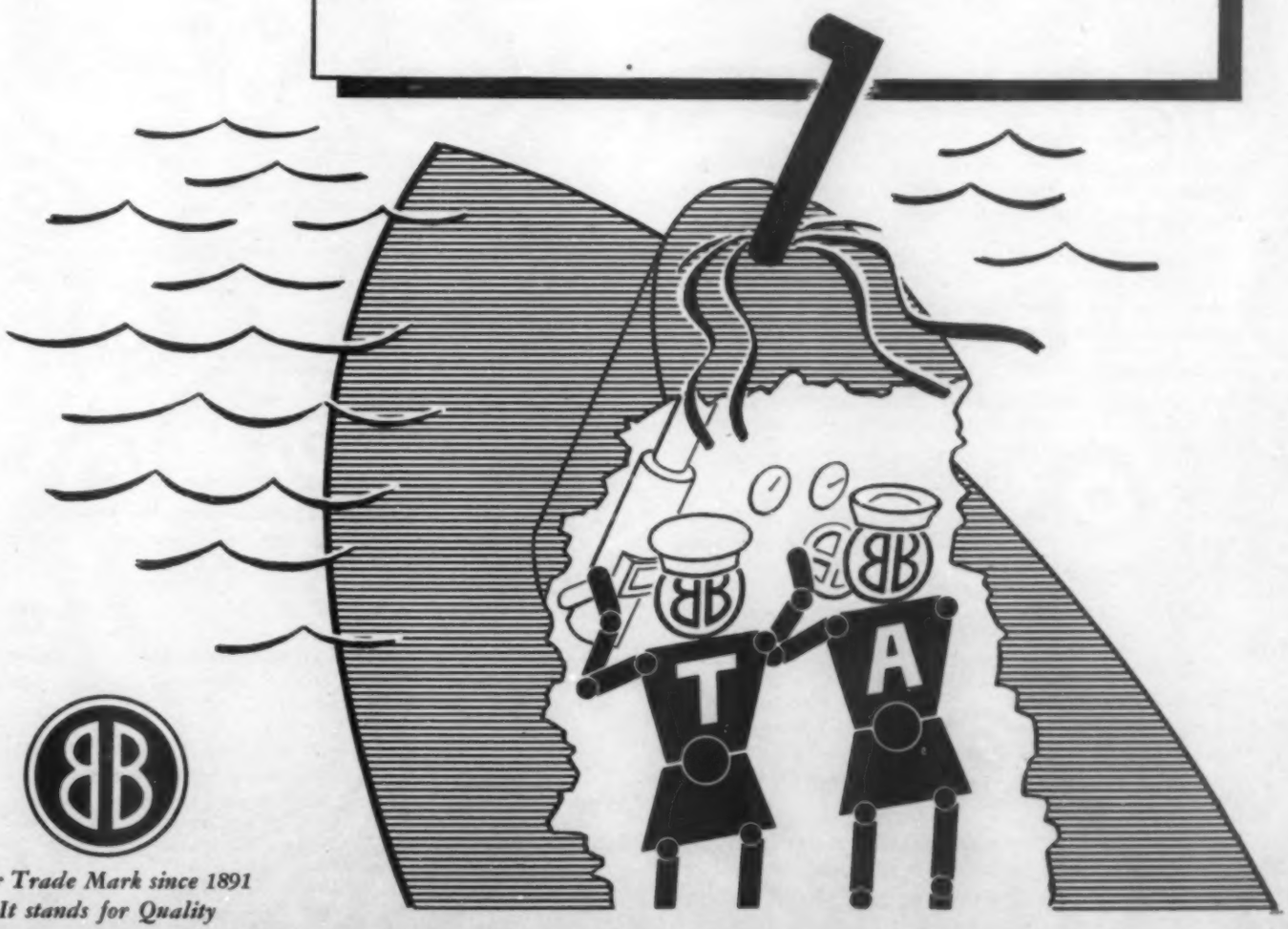

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MOLDING. H. C. Guhl (to Westinghouse Electric & Mfg. Co.). U. S. 2,292,118, Aug. 4. A molded article with a base of phenolic resin impregnated cellulosic fiber and a surface of partially impregnated fiber.

FLEXIBLE PLASTIC. R. L. Sibley (to Monsanto Chemical Co.). U. S. 2,292,164, Aug. 4. Condensing diphenyl with an alkylene dichloride in presence of aluminum chloride to make an extensible resin.

ABRASIVE DISK. F. O. Albertson (to Albertson & Co.). U. S. 2,292,261, Aug. 4. A resin disk reinforced with sisal fiber is faced with absorbent paper carrying a binder for abrasive particles.

FILLING CONTAINERS. Thos. M. Royal. U. S. 2,292,295, Aug. 4. A method and apparatus for filling containers made of thermoplastic sheet material.

FOILS. G. F. D'Alelio (to General Electric Co.). U. S. 2,292,332, Aug. 4. Cellulose ester, ether or ether-ester wrapping foils containing an arylsulfonylmorpholine.

ACETOACETYL RESINS. G. F. D'Alelio (to General Electric Co.). U. S. 2,292,333–4, Aug. 4. Reacting an aldehyde with bis(acetoacetyl)-ethylenediamine or with acetoacetanilide or a halogenated derivative thereof.

GUN STOCK. M. Carpenter and F. T. Green (to Savage Arms Corp.). U. S. 2,292,351, Aug. 11. A rear stock for guns is made of molded plastic with a hollow thin-walled rear portion.

LIGNOCELLULOSE. J. G. Meiler (to Marathon Paper Mills Co.). U. S. 2,292,389–90, Aug. 11. Converting lignocellulose to a molding composition yielding articles with high wet and dry strength and low water absorption.

MOISTUREPROOF FOILS. J. A. Mitchell (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,292,393, Aug. 11. Moistureproofing wrapping foils with a cellulose derivative and wax lacquer with a methacrylate resin promoter.

POLYETHER RESIN. H. S. Rothrock (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,292,406, Aug. 11. Forming resins from potentially reactive mixtures of polyether resins with di- or polysubstituted cyanates or thiocyanates.

TEXTILES. B. J. Habgood, M. Jones and W. F. Smith (to Imperial Chemical Industries, Ltd.). U. S. 2,292,441, Aug. 11. Coating fabric with a mixture of polyethene resin and a sulfurized dichlorohydrin.

POLYAMIDE-PHENOLIC RESIN. W. E. Hanford (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,292,442, Aug. 11. Forming a phenol-formaldehyde resin in presence of a nonfiber-forming polyamide.

POLYAMIDE POLYMERS. W. E. Hanford (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,292,443, Aug. 11. Condensing diisocyanates with diamines.

RUBBERIZED FABRICS. C. M. Langkammerer (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,292,454, Aug. 11. Rubber-coated fabrics are thinly coated with resin, then finished by chlorinating the surface and treating it with an amine or amide.

SULFONAMIDE THERMOPLASTIC. W. H. Moss (to Celanese Corp. of America). U. S. 2,292,464, Aug. 11. Plasticizing film-forming thermoplastics with N-alkanol-N-aryl arylsulfonamides.

FINISH. E. F. Oeffinger and H. G. Stauffer (to E. I. du Pont de Nemours and Co., Inc.). U. S. 2,292,468, Aug. 11. A finish comprising a plasticizer, an alcohol-modified urea resin and a rosin-modified alkyd.

MOLDING CELLULOSE ACETATE. W. E. Gloor (to Hercules Powder Co.). U. S. 2,292,516, Aug. 11. Hot-pressing cellulose acetate in a closed mold and cooling before removing the molding.

COATED PAPER. John Helfrich. U. S. 2,292,518, Aug. 11. Coating paper with a fusible flexible waterproof film of neutral resin, diamyl phthalate and a reaction product of magnesia and dammar gum.

FISHING POLE JOINT. Claude C. Hiner. U. S. 2,292,519, Aug. 11. Tubular reinforcing collars of wood-like plastic for fishing pole joints.

MATERIAL FOR CASTS. S. P. Lovell (to Castex Laboratories, Inc.). U. S. 2,292,531, Aug. 11. Preconditioned cast-forming material is made with a fibrous base and a composition of nitrocellulose and ethylcellulose applied in such a way as to produce syneresis.

STENCIL. W. H. Nichols (to Remington Rand, Inc.). U. S. 2,292,539, Aug. 11. Use of floc-impregnated rubber chloride sheets as stencils.

INJECTION MOLDING. Alfonso Amigo. U. S. 2,292,593, Aug. 11. Apparatus for injection molding of synthetic plastics in cavities communicating with a pressure chamber.

CASHEW NUT RESIN. S. Caplan (to Harvel Corp.). U. S. 2,292,611, Aug. 11. Polymerizing the residue from destructive steam distillation of cashew nut shell liquid.

PLASTICIZED RESIN. F. A. Bent and F. G. Byrne (to Shell Development Co.). U. S. 2,292,734, Aug. 11. Plasticizing polyvinyl acetal resins with a partially hydrogenated mesityl oxide condensation product.

CHLORINATED RESINS. A. Blömer, W. Becker and R. Hebermehl. U. S. 2,292,737, Aug. 11. Chlorinating a rubber-like synthetic resin in an inert solvent, e.g., a butadiene polymer of the type which is compatible with drying oils.

PRINTING INK. C. Ellis (to Ellis Laboratories, Inc.). U. S. 2,292,748, Aug. 11. A quick-drying ink containing an acetone-formaldehyde resin.

VIBRATION DAMPERS. W. H. Bagley, Jr., and T. W. Halloran (to Composite Materials Corp.). U. S. 2,292,813, Aug. 11. Compounding a coumarone resin with a smaller amount of rubber and a larger amount of an inorganic filler for damping vibrations in motor vehicles.

MOLDING LENSES. Wm. E. Williams. U. S. 2,292,917, Aug. 11. Molding thermoplastics in doubly convex form in a mold which is jacketed for circulation of heating or cooling liquids.

QUATERNARY AMMONIUM RESINS. L. H. Bock and A. L. Houk (to Rohm and Haas Co.). U. S. 2,292,921, Aug. 11. Polyhydroxy sizes such as those made from starch or polyvinyl alcohol are insolubilized by reaction with aldehyde derivatives of quaternary ammonium compounds.

OLEFIN RESIN. Robert C. Hills and Maxwell M. Barnett. U. S. 2,293,023, Aug. 11. Reacting sulfur dioxide with an olefin in presence of a liquid which is not a solvent for the resin.

LACQUER BASE. Laszlo Auer. U. S. 2,293,038, Aug. 18. A coating composition which does not flocculate comprises an oil dispersed in a cellulose ester or ether lacquer base.

EMULSION PLASTIC. F. J. Myers (to Resinous Products and Chemical Co.). U. S. 2,293,164, Aug. 18. Making a rubbery infusible plastic from an aqueous dispersion of an oil-modified alkyd and an alcohol-modified urea resin, prepared with a dispersing agent and a protective colloid.

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Publications

Write direct to the publishers for these booklets. Unless otherwise specified they will be mailed without charge to executives who request them on business stationery. Other books will be sent postpaid at the publishers' advertised prices

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Volumetric Analysis. Vol. I. Theoretical Fundamentals

by I. M. Kolthoff and V. A. Stenger

Interscience Publishers, Inc., 215 4th Ave., New York, 1942

Price $4.50 **309 pages**

Available information regarding equilibrium constants, oxidation potentials, solubility products, indicators, titration errors and adsorption and coprecipitation phenomena pertinent to volumetric analysis of inorganic and organic materials is comprehensively reviewed. The further scientific development of titration methods will be stimulated by this thorough revision and enlargement of a book originally published by the senior author in 1927. G. M. K.

Pioneers of Plenty—The Story of Chemurgy

by Christy Borth

Bobbs-Merrill Co., 468 4th Ave., New York City, 1942

Price $3.50 **410 pages**

Originally published in 1939, this book has just been re-issued in a new and enlarged wartime edition. Written in popular, readable style, the stories of the "Pioneers of Plenty," those chemists and scientists who have laid the groundwork for the transition from the machine age to the chemical age, make timely reading during a period of our development when the creative aspect of our civilization is being called upon to exert every effort to counterbalance the destructive forces at work. "Chemurgy," as defined by the author, is "a program of correlated processes by which hitherto unused raw materials and wasted labor are put into productive and socially useful forms by the aid of those modern alchemists, the creative chemists who have lately been demonstrating that you *can* unscramble omelets, sink ducks, and make silk purses out of sows' ears."

It is the story of these creative chemists that is told in these pages; the story of their efforts and their achievements. The book is filled with personalities and personages whose work has already affected the lives of most of us, and will affect them in greater measure after the war is over. Dr. William Jay Hale, Dr. Charles J. Herty, Francis Patrick Garvan, Irénée du Pont, Robert A. Boyer and Dr. Leo H. Baekeland are a few of the figures, each the hero of a dramatic story.

Mechanical Engineers' Handbook, 4th Edition

Lionel S. Marks, Editor

McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, 1941

Price $7.00 **2274 pages**

This revision of a handbook which has been used by engineers and designers for over 25 years has more than 800 tables and 1700 illustrations prepared by the 90 contributors to the volume. Its 16 sections cover such subjects as strength of materials, machine-shop practice, pumps and compressors, power generation, materials of engineering and mathematical tables. The material is arranged in handy reference form and topics are easily located by means of an 88-page index. G. M. K.

Chemical Dictionary

by F. H. Campbell

Chemical Publishing Co., Inc., 236 King St., Brooklyn, 1942

Price $2.50 **85 pages**

This is a compilation of approximately 1000 terms used in publications pertaining to chemistry. It is intended to cover primarily the new words and physical units not ordinarily defined in textbooks of chemistry. G. M. K.

★ IN COMMON WITH HUNDREDS OF OTHER RAPIDLY expanding firms throughout the country, the Boonton Molding Co., Boonton, N. J., has had the problem of absorbing into their organization large numbers of new employees. At least one aspect of the problem has been disposed of by the publication of a small pocket-size booklet which incorporates all of the basic information that a new employee should know about the industry in which he is now working, about his firm, and about its place in the national war effort. Written in simple, nontechnical language, and illustrated with sprightly thumbnail sketches, the sixteen pages of text cover a general discussion of the types of material used in the plastics industry; construction of molds; machinery; fabrication operations and other aspects of the work in a molding plant. In addition, there is a brief statement of company policy, as well as an explanation of employee-employer relationship with regard to such important matters as hours, health, taxes, etc.

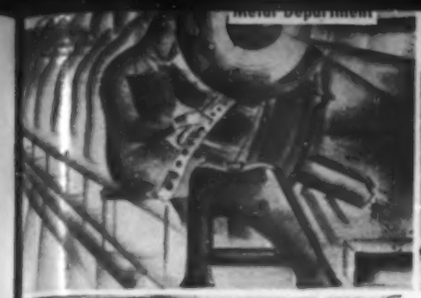
★ A NEW SUPPLEMENT TO THEIR GENERAL CATALOG is now available from Jas. H. Matthews & Co., Pittsburgh, Penna. A wide variety of steel stamps and steel type holders for diversified stamping needs are illustrated and described in detail, with photographs showing suitable applications.

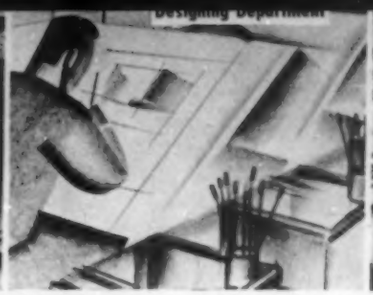
★ MANUFACTURERS SCREW PRODUCTS, WEST HUBBARD St., Chicago, Ill., announce the publication of a new screw products catalog, in which all items listed in the 96 pages conform to the revised suggested stock size lists, as per maximum price regulation No. 147 of the Office of Price Administration, dated May 23, 1942. The catalog contains prices and complete technical data including weights and dimensions of various items shown. The book is available to engineers or purchasing agents who request it on their business letterheads.

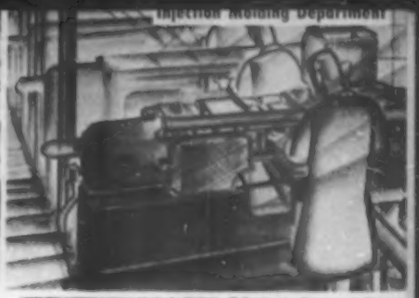
★ A NEW 21-PAGE BOOKLET DISCUSSING PROPERTIES and applications of a series of terpene solvents has just been issued by the Naval Stores Department of Hercules Powder Co., Wilmington, Del. The booklet emphasizes that turpentine, which is composed of terpene hydrocarbons, used for many years as a solvent and thinner for protective coatings, is just one of several terpene solvents available today. Thinners and solvents discussed have been grouped under five classifications in accordance with their major constituents. Technical graphs on A.S.T.M. boiling ranges and distillation ranges, and on the evaporation rates at 100° C. of the company's terpene solvents, are included in the booklet.

★ THE CALIFORNIA INSTITUTE OF TECHNOLOGY, Pasadena, Calif., has just issued an illustrated report on their industrial design section's first year of activities. The booklet contains a discussion of some of the problems with which students were presented as part of the curriculum, and the manner in which these problems were handled.

★ BULLETIN NO. P-1 FROM THE HODGMAN RUBBER Co., Framingham, Mass., is devoted to description and illustration of saran tubings and fittings available from that company. Two tables, one recording chemical resistance and the other bursting pressure, are included, as are listings of mechanical, thermal, electrical, optical and general properties of saran tubing and fittings.







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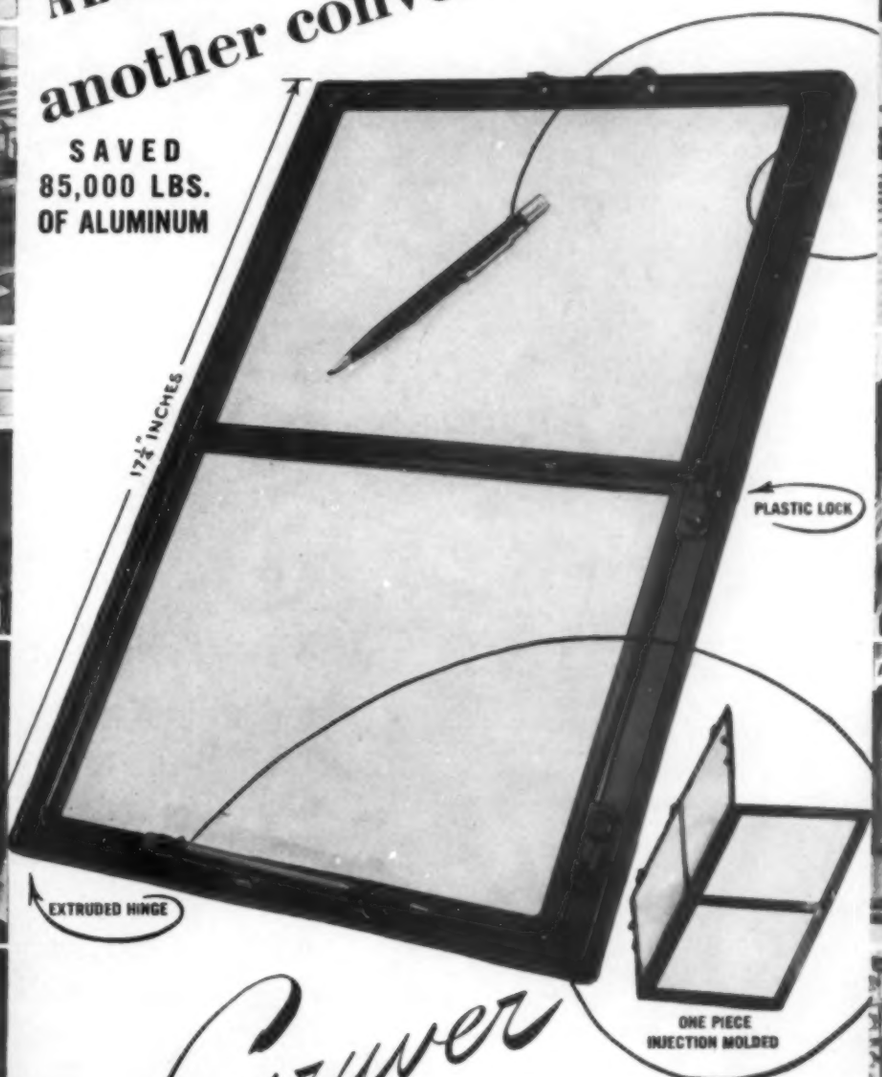

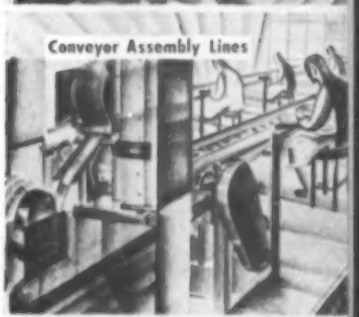

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In the plastics picture

★ THE MEETING OF THE SOCIETY OF THE PLASTICS Industry on Oct. 12 and 13 at the Westchester Country Club, Rye, N. Y., is to be held mainly for the purpose of more thoroughly acquainting the members of the industry with the plastics problems of our armed services as well as those of other branches of the Government. As will be readily realized, serious shortages have been and are being uncovered as industry moves into high gear in its war matériel output. If serious bottlenecks are to be avoided, these potential shortages must be recognized by all those in a position to aid in meeting the problem unless actual deliveries to the services are to be affected.

While the plastics industry, both collectively and individually has done a remarkable job in developing plastics products to replace strategic metals and in creating new ones, much more remains to be done along this line. The meeting at Rye will provide an exceptional opportunity to meet with members of the services in charge of plastics applications and specifications, and their problems will be dealt with specifically both in the general meeting and by the technical committees of the Society.

In addition to exploring the war matériel requirements of the Government and in developing ways and means to meet them, many other important industrial problems are scheduled for discussion. Speakers from WPB and OPA are expected to be on hand to provide an opportunity for members to learn at first hand of new or probable developments in these important Government agencies which may affect their operations and to discuss the problems of existing regulations. There will, of course, be speakers of international renown on both days who will deal with some of the broader aspects of the industry's problems.

★ DR. GORDON M. KLINE, CHIEF OF THE PLASTICS Division, National Bureau of Standards, and technical editor of MODERN PLASTICS, recently returned from Great Britain where he spent a month observing plastics developments in progress. During his visit, he was a guest speaker at the luncheon meeting of the British Plastics Federation and annual meeting of the Institute of the Plastics Industry. Dr. Kline made the trip as a representative of the U. S. Government in response to an invitation from the British Ministry of Supply. He visited the various Government laboratories concerned with plastics and many of the British plastics plants.

★ ON THURSDAY SEPT. 10, THE AMERICAN INSULATOR Co., New Freedom, Penna., celebrated Garden Day. The occasion was marked by the presentation of two plaques by MODERN PLASTICS magazine for the two outstanding gardens in the project, and by a showing of the magazine's film, *The Magic of Modern Plastics*.

The garden plan grew out of measures taken to beautify the fence which circles the plant as an anti-sabotage precaution. The results were so gratifying that the project was extended to embrace other eyesores on the grounds, the gardens to be tended by various departments, and prizes to be awarded for the best ones. The entire plan has been so successful that George Johns, president of the company, expressed the hope that this year's Garden Day might be the first of a series of annual celebrations.

★ PLASTIC WAR PRODUCTION ASSOCIATION, A group of eastern plastics firms with headquarters at 122 East 42nd St., has been certified by the WPB as a war production association appropriate in form and character to the fulfillment of the objectives of the War Production Board. The certification has been formally approved by the Attorney General. The purpose of the PWPA, as expressed in their announcement, is to pool the engineering, research and manufacturing facilities of their members for the benefit of the various Government branches placing war contracts. Facilities of PWPA members are widely varied as to types of work, and include presses, machinery and finishing equipment capable of producing such items as fuze bodies (various types), uniform insignia, helmet liners, gas mask valves and guards, machine gun grips, pistol grips, gun stocks, bayonet scabbards, shell components, range finder indicators, horse and mule mask parts, crystal holders, bomb release brackets, bomb housings, shipping plugs for bomb ends, shell windshields, aircraft fairlead insulators, signal lamps and numerous other things needed for the war effort. In most instances, plastics is replacing in such items critical metal materials needed in other applications. One of the most important functions of the PWPA will be to develop through research and experimentation, and in close cooperation with the various Procurement Offices of the Armed Forces, new applications of plastics which will result in substantial and necessary conservation of vital metals.

The Executive Committee of PWPA includes Leo Adenbaum, Accurate Molding Corp., Brooklyn, N. Y.; Maurice Witt, Atlas Appliance Corp., Brooklyn, N. Y.; Adolph Cohn, Glassoloid Manufacturing Co., N. Y. C.; Leon Lautin, Eagle Molding Co., L. I. C.; Charles Fischett, National Fabricating Co., South Ozone Park, L. I.; C. W. Marsellus, Universal Plastics Corp., New Brunswick, N. J.; Joel Kronman, Victor Metal Products, Brooklyn, N. Y.; R. D. Werner, R. D. Werner Co., Inc., N. Y.

★ THE POLYTECHNIC INSTITUTE OF BROOKLYN, New York, announces the addition of new courses to its fall curriculum. One is called The Mechanism of High Polymeric Reactions, scheduled to be held every other Saturday beginning October 3, under the direction of Professors H. Mark and C. E. Waring.

The second is a course in the reading of Chemical Russian, scheduled for Tuesday evenings throughout the year. This course is designed to give a mastery of the grammatical principles and vocabulary necessary for the translation of technical articles from Russian reference books and periodicals. The course will be taught by Dr. Karl Steik.

Beginning Oct. 1, a course in the Technology of Resins and Plastics will be given on Thursdays at 8:00 P.M., under the direction of Dr. Paul F. Bruins. This will take the form of a series of lectures by men prominent in the industry, each speaking on a phase of the subject with which his firm is associated, or to which he has made a personal contribution. A list of specific topics to be covered in the course will be found in MODERN PLASTICS *19*, 63 (Aug., 1942).

★ J. EARL SIMONDS, PLASTICS CONSULTANT, HAS been appointed assistant technical director of the Eastern Division of Plastics Industries Technical Institute, 122 E. 42nd St., N. Y. C. After spending two months in the research laboratories of the Institute in Los Angeles, Calif., he is now back in New York, where he will handle consulting and research contacts with clients in the East and Middle West. Dr. John P. Trickey, who came to New York about a year ago to launch the educational program of the Institute in the East, has returned to Los Angeles to resume his post as assistant technical director.

Sorry!

★ ON PAGE 58 OF THE JULY ISSUE IN THE STORY called "Converting for Uncle Sam," it was erroneously stated that cellulose acetate was specified by the Chemical Warfare Service for the manufacture of gas mask lenses. The fact is, as pointed out in a letter from Rohm & Haas Co., that the Chemical Warfare specifications do not list any specific type or types of plastics but list specifications which both cellulose acetate and acrylics meet. Since the price differential gives cellulose acetate an advantage, most molders are using this material, although some are molding lenses of acrylics.

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1 Alkali and acid resistant.

2 Excellent finishing characteristics.

3 Easily machined or turned.

4 Non-hygroscopic.

5 Highest radio and electrical insulating characteristics.

6 Economical, especially for moldings of large size.

7 Highly desirable for precision parts with metal inserts.

8 Available in unit moldings up to 10 feet by 3 feet by 28 inches.

9 Adaptable to a wide range of industrial uses.

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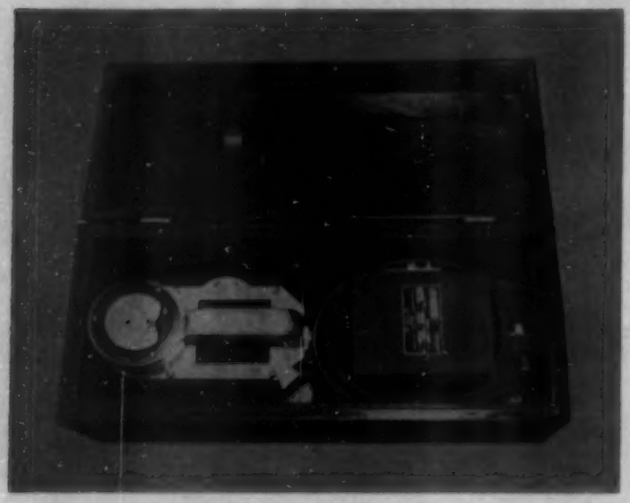


★ A MOISTURE METER FROM WILBUR INSTRUMENT Co., Portland, Ore., makes possible a reading of moisture percent as soon as the instrument is brought in contact with the material being tested, following a short initial warming up period for the tube. The meter includes the instrument itself, a constant-temperature transformer, an extension cord and plug for connection to a 110-volt AC power source and a carrying case. The instrument measures 9 in. by 5 in. by 7 inches. It employs an electronic tube, operates by dielectric capacity rather than by resistance. Depth of penetration on wood products is given as 6 to 8 in., and the effective area is approximately 10 in. in diameter. Representative materials that can be tested, according to the manufacturer's description, include lumber, pulp, paper, grain, flour, plastics (which do not have too high a dielectric capacity) and chemicals.

★ THE DEVELOPMENT OF A BENCH MODEL TURRET Lathe for production to close tolerances on chucking operations or bar work is announced by the South Bend Lathe Works, South Bend, Ind. This lathe has a 10 in. swing over the bed and saddle wings, $1^{3}/_{8}$-in. hole through the headstock spindle and 1-in. collet capacity. It is described as being well adapted to second operation work. The handlever operated bed turret indexes automatically and has an adjustable stop for each of the six turret faces. The lathe is equipped with both a compound rest cross slide and a handlever cross slide, which are interchangeable. The latter is furnished with both front and rear tool blocks which provide three tool positions. Twelve spindle speeds are delivered by the underneath motor drive and back gears, from 97 to 700 r.p.m. An assortment of attachments and accessories simplify tooling for specialized work or second operation jobs, according to the company.

★ COLD ROOM AIR CONDITIONERS SAID TO PROvide constant temperatures as low as −50° F. to −80° F. are now available for manufacturers who require this equipment from Niagara Blower Co., New York City, in the shape of their Niagara "No-Frost" Method. This new equipment consists of coolers operated in stages, and is reported as capable of giving constant operation without interruption by reason of ice or frost forming on cooler coils or because of corrosion of equipment from contact with brine or calcium.

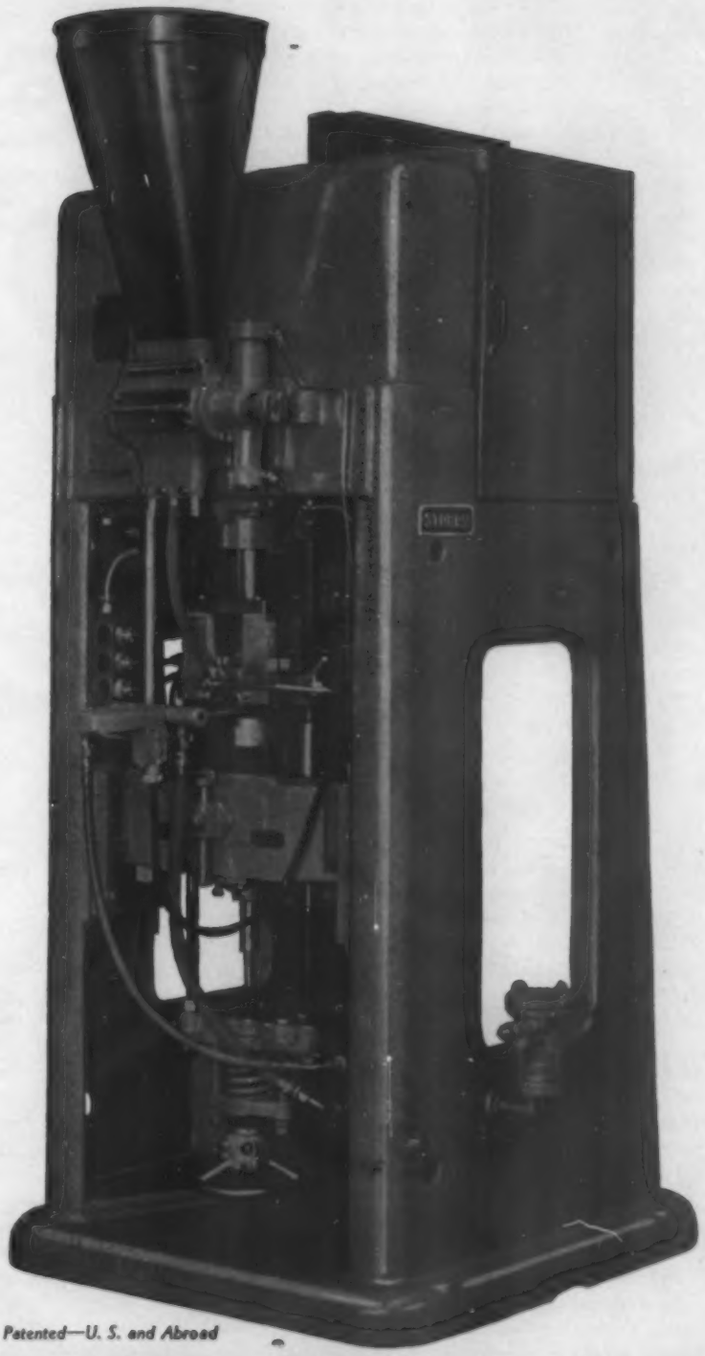
★ A 200-TON CAPACITY HYDRAULIC STRAINING press manufactured by the Watson-Stillman Co., Roselle, N. J., with two cylindrical containers, each 10 in. in diameter and 33 in. deep, is said to strain or filter fluids under a 2000-lb. per sq. in. pressure. The press is completely self-contained, with a 20-h.p. motor, 18-G.P.M. pump and oil tank. The unit stands 14 ft. high, and weighs 15,000 lb.

★ ELASTIC STOP GANG CHANNEL NUTS FOR INdustrial use where a multiple, self-locking, bolted fastening is required are offered by the Elastic Stop Nut Corp., Union, N. J. The strips of nuts are factory assembled, and can be riveted or fastened to the structure on which they are to be used. They consist of specially designed Elastic Stop nuts with four lugs at the base, installed at specified intervals in a metal channel strip which is preformed to accommodate the nut lugs under longitudinal flanges. The channel strip is pierced for the required nut size and spacing, and the nuts are held in place by depressions in the channel. They are furnished in standard six-foot lengths.

★ THREE NEW LARGE CAPACITY PORTABLE COOLant pumps for automatic application of coolants to cutting tools are available from Gray-Mills Co., Chicago. The models designated as heavy duty "A" series pumps G-2A, G-3A and G-4A (above), are reported to have been designed to prolong tool life, speed up production and lower operating costs. Features of this series are reported to be complete portability, controlled flow from a few drops to a full stream, baffle plate construction and forced settling fixture to keep coolant fluids clean at all times (described as advantageous for abrasive grinding, milling and honing machines), larger tank capacity (10 and $12^{1}/_{2}$ gal.) to eliminate frequent coolant changes, ball bearing type motors, replaceable driving gears, cleanout plug, flexible power shaft coupling and easy access to all working parts.

Mold Automatically

To Meet Today's Production Needs ... and Tomorrow's Competition



Patented—U. S. and Abroad

You conserve when you mold Automatically. Conserve molding material . . . 8% to 10% or more. Conserve tool steel . . . for automatic molds with only one, or few cavities, require only a fraction of the steel that goes into the conventional large mold. Conserve tool-makers' time . . . for automatic molds are quickly made, weeks ahead of large molds.

You conserve molding time . . . 50% or more in many cases, for automatic operation saves every split second. You conserve molding labor . . . because automatic molding requires a bare minimum of operating attention, a whole battery of machines being maintained in full operation by a single skilled molder.

Automatic moldings are of the highest quality . . . meet the most exacting Army and Navy specifications with rejects less than 3% in specific instances. Automatic production is continuous, rapid, 10,000 or more moldings per week, per mold cavity.

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F.J.Stokes MOLDING EQUIPMENT FJS Est. 1895

Washington Round-Up

Current news, Government orders and regulations affecting the plastics industry, with analyses of the plastics situation

NEW MOLDS FOR OLD

Molders who want to replace worn or damaged molds with new ones will be helped to do so by using a plan that is being encouraged by WPB. The plan is a simple one and is not entirely new in that it is similar to plans that are being used in other industry circles. The plan calls for a trading in of old molds for new ones on a pound for pound basis.

Here is how it works: When a molder who needs a new mold sends in his PD1A or PD25F to WPB, he should enclose a letter stating that he has an old mold or molds of comparable weight to turn in to the mold maker in trade for the metal that is to be used in the new one. Under this plan the molder's application will be given more favorable consideration. The priority assistance granted will be conditioned on his turning in the old metal, and this condition will be noted on the priority certificate when issued. It will not be necessary to trade in metal for metal, that is, alloy for alloy, for WPB feels that this phase of the problem will balance itself. All that is necessary is that the weight of the old mold be approximately equal to the weight of the new one.

This scheme has many favorable angles. It will help the molder to get a rating which would be higher than that which he would ordinarily be granted. This will tend to save time which might be lost because of his having had a lower rating. Another angle is that it starts scrap toward people who are going to use it.

Of course this plan will be given a favorable reception by WPB only where the new mold is going to be used to turn out essential products. It cannot be used to replace molds which are used for non-essential civilian orders. A baby rattle mold, for example, could not be replaced by this method. The whole purpose of the plan is to conserve metal, facilitate defense production and help to make new molds available to the plants that are cooperating in the war effort.

OPA PRICE REGULATIONS

A revision of the General Price Order with reference to the plastics industry was effected recently and presented at meetings held under the sponsorship of the OPA on Sept. 4 in Chicago, and on Sept. 8 in New York. Recognizing that the General Price Order had definite limitations for regulating prices of molded and fabricated articles, the OPA has set up a plan whereby the following branches will have jurisdiction over the various divisions of the plastics industry.

1) The Chemicals Branch will cover all plastics raw materials including molding compounds, sheets, rods, tubes and liquids, and this division of the industry will be regulated by the General Maximum Price Regulation. All companies in this division must submit prices on new materials for approval to this branch of OPA.

2) Machinery Branch will cover all molding, fabricating and machinery, and this division will be regulated by the amended Machinery and Parts Order No. 136. Prices in this section will be adjusted on the basis of Mar. 31, 1942, costs, including labor costs then prevailing.

3) Consumer Durable Goods Branch will cover all finished plastic products such as combs, buttons, etc. This division will be regulated by the General Maximum Price Order, and Order No. 188.

4) Paper and Paper Goods Branch will cover fabricated cellophane products, and this division will be regulated by General Maximum Price Regulation Order.

Although there is still no provision for increased labor costs since Mar. 31, 1942, to be taken into account in the pricing of plastics products, it is, of course possible for manufacturers to submit upward price adjustments to OPA for approval.

Soluble Nitrocellulose—Two changes have been made in Order M-196 relating to soluble nitrocellulose. Nitrocellulose suitable for dynamite manufacture is removed from the restrictions of the order. Undissolved film scrap is removed from allocation control, with authority given WPB to issue directions for delivery and use.

• • •

Cyanamid Derivatives—Amendment No. 1 to General Preference Order M-165 places under complete allocation control several important cyanamid derivatives not previously covered. Cyanides, melamine, guanidine and dicyandiamide, used in nonferrous mining, explosives and plastics, are included.

• • •

Cuprammonium Rayon Yarn—A percentage of this type of yarn must be set aside by the producer for export to South American countries, according to an amendment of Rayon Yarn Allocation Order M-73-A.

• • •

Furfural—With the issuance of General Preference Order M-224 on September 5, furfural was placed under complete allocation and control. The order forbids any person to deliver, accept delivery, or use furfural after October 1, 1942, without specific authorization by the Director General of Operations.

• • •

Priority Ratings—About three hundred men have been trained and are being sent to WPB regional offices and Army and Navy field procurement offices to supervise issuance of priority ratings on war contracts in the field, it has been announced by J. A. Krug, Deputy Director General for Priorities Control.

• • •

War Risk Insurance—Effective September 1, shipments of such commodities as industrial chemicals, nickel and alloys, manganese ore, soap and toilet preparations, woodpulp, gems, diamonds, jewelry and metal articles, will take the rates which prevailed under insurance granted by the War Shipping Administration in the month of July and published in bulletins C-5 and C-6 of the War Shipping Administration.

• • •

Machine Catalog—A comprehensive survey is in progress by the Office of Price Administration to check on compliance with the price ceiling on used machinery. The survey is being handled in such a manner, however, that the resulting information will be compiled in a complete catalog of all of the equipment available for sale. Machine tools are not included in the survey, but all forms of processing machinery, electric motors, circuit breakers and transformers, pumps, blowers, construction and mining equipment, chemical machinery, railroad equipment, etc., will be included. About 25,000 pieces out of an estimated 500,000 are already listed in the OPA files.

• • •

Resin Coated Cloth—OPA has authorized a premium of one-half cent per yard for sheetings or print cloths where made for use in product manufacture to U. S. Army specifications which employ synthetic resin coated sheetings or printed cloths. Effective September 15, 1942, for raincoats, etc.

• • •

Contract Branch—The Director General of Operations of WPB announced on September 3 that as of September 15, the Contract Distribution Branch in Washington would be discontinued, and its functions taken over by the Smaller War Plants Division of WPB and the Smaller War Plants Corp.

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Shatterproof eye-appeal

CELLUPLASTIC vials are being used in the War Effort. . . . Every job undertaken by us has unmistakably demonstrated the advantages of CELLUPLASTIC, in container form or in molded parts. It offers a resilience that withstands usage!

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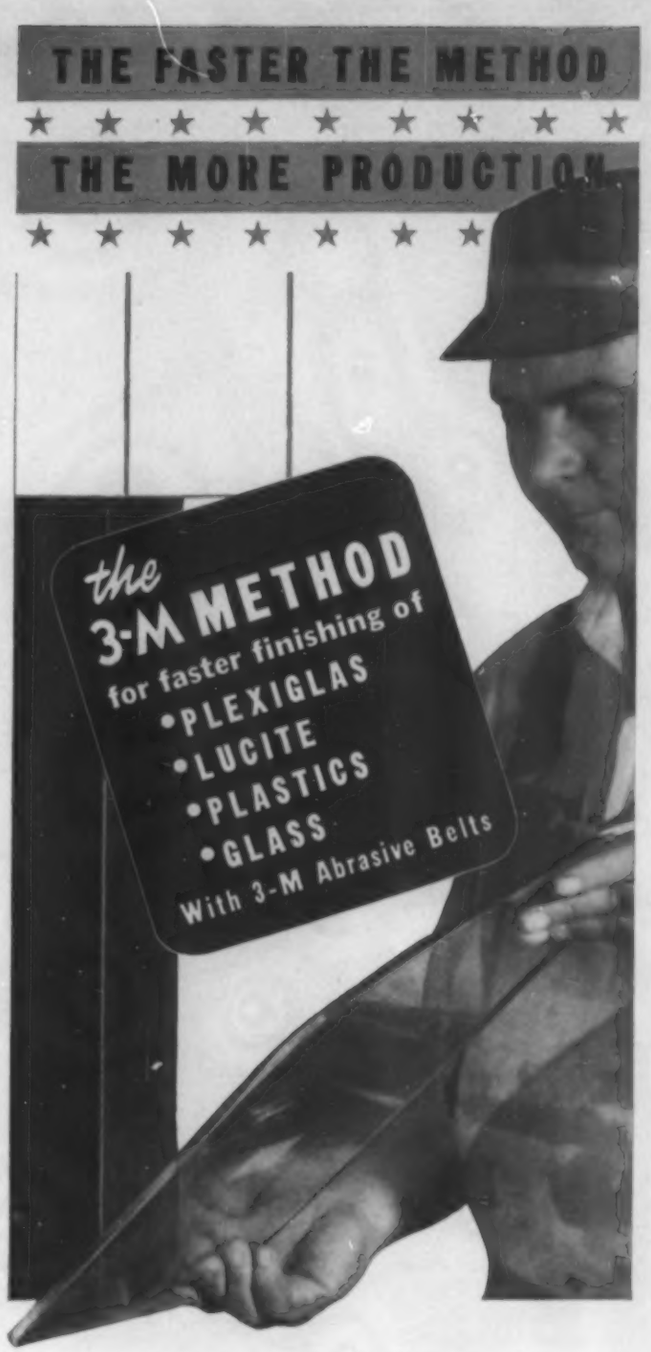

INSURE INCREASED SPEED and GREATER OUTPUT by using the 3-M Method—the quick, easy way to remove sprues and mold lines—to bevel without burning or scorching or causing plastic flow.

If you have new production problems sanding these materials, our sales and technical engineers will gladly help you.

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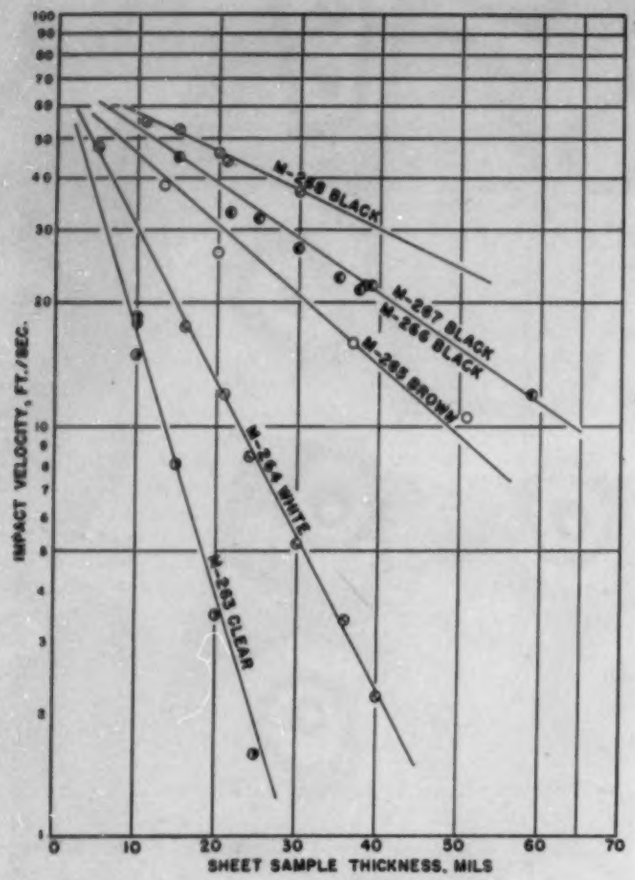

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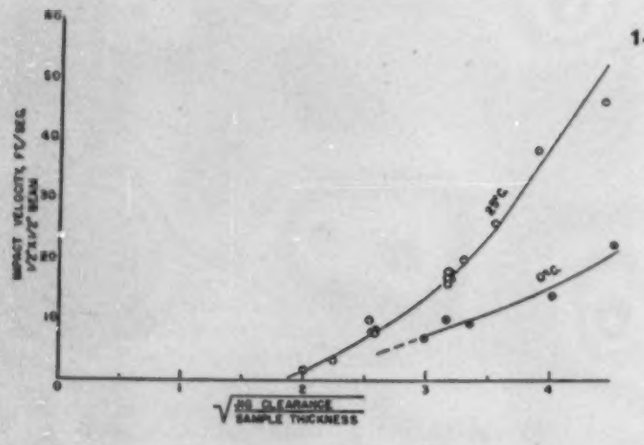

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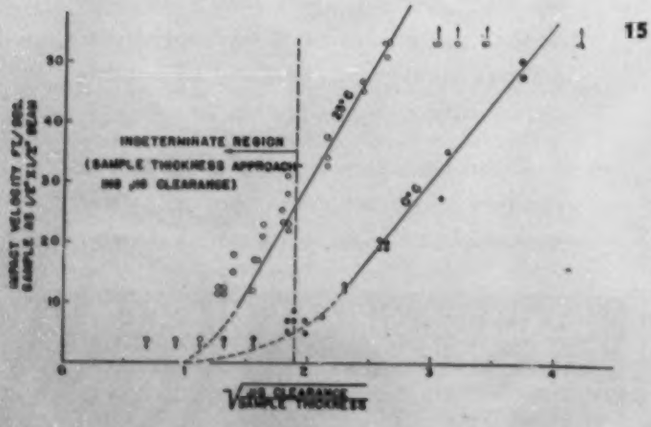

15

Strength of plastic sheet

(*Continued from page 87*) of sheet stock at high velocity on guillotine cutters, and the cold-drawing of flat sheet stock in an embossing press operated at high velocity.

Versatility of impactometer test method

The impactometer has been used to evaluate the effects of compounding and processing variations and various fabrication methods on the toughness of the plastic sheet stock produced. The effect of internal strains on the sheet toughness has been determined. Surface crazing and embrittlement, produced by active solvents in lacquer coatings and adhesives on copolymer vinyl chloride-acetate sheet stock, have been determined with success. An important consideration has been the effect of temperature on the impact resistance of plastic sheet stock. Throughout the trials, the impactometer was located in a constant-temperature room in which the temperature was controlled within narrow limits. Although the humidity was controlled, the copolymer vinyl chloride-acetate sheet stocks are not affected by humidity changes. All sheet stocks tested were conditioned for minimum periods of three hours previous to the impact testing at constant temperature (25° ± 2° C.). A number of trials were conducted in a cold room in which the ambient temperature was 0° C. Tests conducted at 0° C. were made on plastic sheet samples conditioned for a minimum of eight hours previous to the tests.

Figure 14 shows the effect of temperature on the impact velocity at 25° C. and 0° C., respectively. The material, M-263 Clear, has suffered an approximate 50 percent decrease in impact resistance by a 25° drop in the temperature of the test. The method of expressing the relation of jig clearance and sample thickness has been previously described. A number of sample thicknesses were tested at various jig clearances, under the temperature of the test, to determine the relation shown. Figure 15 shows the effect of temperature on the impact resistance of compound M-266 which is considerably tougher than compound M-263 at comparable temperatures. The relative decrease in the impact resistance of M-266 is of the same order of magnitude as that of M-263 when each material was tested at the lower temperature.

The unsuitability of the excess-swing pendulum test as a toughness test for copolymer vinyl chloride-acetate plastic is shown in Table I. The lack of correlation in the results obtained by the impactometer and the notched Izod pendulum, respectively, on the same plastic compound is significant. The series of compounds shown all have various degrees of impact resistance. This is shown by the variable impact velocities obtained by the impactometer and confirmed in similar compounds in actual service. Despite the various degrees of serviceability demonstrated by the compounds shown, their notched-bar impact strengths bear no relation to the order of their respective resistance to failure by the impactometer test. (*Please turn to next page*)

13—*Rectification of experimental data for six copolymer vinyl chloride-acetate sheet stocks in accord with equation 4. Clearance 0.100 in., 25° C.* **14**—*Effect of temperature on the impact resistance of copolymer vinyl chloride-acetate sheet compound M-263 clear. Data plotted in accord with equation 2 at two temperatures.* **15**—*Effect of temperature on the impact resistance of copolymer vinyl chloride-acetate sheet compound M-266 black. Data plotted in accord with equation 2 at two temperatures*

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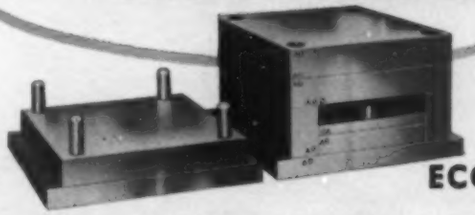

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In Table II is shown the relative comparison of the impact resistance of a number of types of plastic sheet tested. Previously, the study of impact resistance in rigid sheets of copolymer vinyl chloride-acetate showed that a tremendous increase in impact resistance of sheets of this plastic could be imparted to the stock by modifications in compounds and processing. This is obviously true for all plastic sheets and, consequently, there can be no generalizations made regarding the relative toughness of the various plastics on the market. Practically all of the commercial plastics in use today, both thermosetting and thermoplastic, are combinations of base resin and compounding agents added for specific purposes. Various grades of the base resin itself may be used for imparting the proper degree of flow, etc., in the fabrication of the plastic compound. Accordingly, the results shown in Table II are the average results for only a few of the various grades of sheet stock of a specific type. The impact resistance of the copolymer vinyl chloride-acetate sheets shown are representative of a range of impact properties available in commercial grades of this plastic.

The results shown for the cellulose derivatives are averages from determinations made on a few random stocks purchased on the open market. Unfortunately, no means were readily available for the determination of the specific formulations of the cellulosic sheets shown and what relation the samples bore to the standard commercial grades.

The polystyrene, significantly more brittle than the cellulose esters or the vinyl copolymer, was representative of solution-cast film, a commercial item. Samples for test were prepared in a variety of thicknesses by laminating a plurality of thin films in a laboratory laminating press.

The laminated phenolics were laboratory samples of commercial materials in a thickness of 0.020 inch. The samples are not necessarily representative of the commercial shapes of phenolics normally used in service applications. Although filled phenolics are seldom used in sheets of this thickness, the results are given for a relative comparison with similar sheet thicknesses in the thermoplastics.

No satisfactory correlation of the impact velocities for the plastic sheet stocks shown in Table II could be made with various other physical properties of the materials. Attempts were made to correlate impact velocity with shear strength, tensile strength, modulus of rupture, rigidity and tear strength (Elmendorf) with little success. Moreover, the impact velocity for a specific plastic sheet compound was completely divergent from its rated notched-Izod impact strength. The nonconformity of the sheet stocks, in their relative toughness and other physical properties, was judged significant and indicative of the existence of impact strength as a separate and fundamental property of the material. Plastics, therefore, are no different from metals and other materials in their respective behavior to static and dynamically applied stresses.

Table I.—Lack of Correlation of Notched Izod Impact Strength and Impact Velocity in Copolymer Vinyl Chloride-acetate Plastic

Compound	*Average impact velocity by impactometer*[a] *Ft/sec.*	*Average notched impact strength*[b] *Ft./lb.*
M-197	1.0	0.10
M-196	3.3	0.10
M-195	3.3	0.27
M-194	7.8	0.33
M-193	12.5	0.33
M-192	16.0	0.22
M-204	12.0	0.25
M-205	14.5	0.25
M-206	18.0	0.25
M-207	19.0	0.30
M-208	23.0	0.23
M-209	26.0	0.17

[a] Polished sheet, 0.020 in. in thickness tested by the impactometer at 0.100-in. jig clearance at 25° C.
[b] Compression-molded notched 1/2-in. by 1/2-in. bars tested on the Izod pendulum (A.S.T.M. D256-37T) at 25° C.

Table II.—Comparative Impact Resistance of Sheets of Various Plastics by the Impactometer Test

Compound	*Average impact velocity for 0.020 in. thickness at 25° C. Ft./sec.*
Copolymer vinyl chloride-acetate:	
M-268	46
M-267	39
M-266	39
M-265	31
M-264	12.5
M-263	3.8
Cellulose nitrate	45
Cellulose acetate	30
Ethyl cellulose	24
Polystyrene	1–
Laminated phenolic:	
Canvas filled	1–
Paper filled	1–

Acknowledgment

The author is indebted to Dr. M. C. Reed of this laboratory for his original conception of the modified impact test for plastic sheet stocks and for aid and suggestions in the development of the test. Acknowledgment is also given to Mr. L. C. Hosfield of the National Carbon Company for his invaluable aid in the design of the impactometer.

Injection molded saran

(*Continued from page 71*) care must be taken to avoid contamination with oil, grease and dirt. It is especially important that every precaution be taken to assure freedom from contamination with rust or metal during the grinding operation, since their presence will cause decomposition of the material when heated. It is best to use reclaimed vinylidene chloride materials in combination with fresh materials rather than to employ them alone. It is recommended that such materials be used in such mixtures to the extent of from 10 to 20 percent of the total.

In order to obtain the maximum in surface gloss on injection molded parts it is suggested that the die cavities be wiped from time to time with a soft cloth slightly moistened with oil. If this and other normal precautions are adopted, parts with excellent physical and appearance characteristics will be readily produced.

Properties of molded parts

The most outstanding property of saran moldings is the resistance they possess to inorganic chemicals and to organic solvents. This has already been discussed and data will be found in Table I, page 71.

Their heat resistance is unusually good for a thermoplastic material. Molded parts may be sterilized by boiling without

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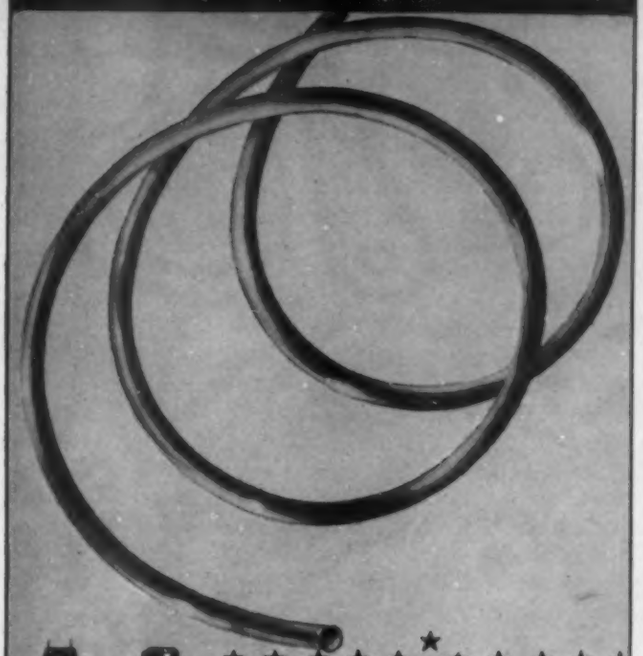

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loss of property or noticeable distortion, weight increase or dimensional change. Because it has a narrower melting range than most other thermoplastics, the material resists flow at temperatures up to within a few degrees of its molding temperature. Comparative flow curves shown in Fig. 10 will serve to demonstrate this feature of the material.

Another characteristic of the moldings which is dependent upon the heat behavior and crystallinity characteristics of the material is the unusually good weld strength they exhibit. Welds in the completed molding are practically as strong as other portions of the part and will resist flexing and shock to practically the same degree as the body of the molding.

The molded parts are dimensionally stable. They exhibit little or no volume change due to the absorption of water or to loss of plasticizer but are subject to change in dimension with changes in temperature as are metals and other materials. The material's coefficient of thermal expansion is 15.8 $\times 10^{-5}$° C. Such parts, as might be expected, age and weather well and retain their original properties over long periods and on exposure to a wide range of temperature-humidity conditions. Continued exposure to sunlight does result in a slight darkening of the material.

TABLE II.—PROPERTIES OF MOLDED SARAN B-115

Extrusion temperature	Up to 375° F.
Injection molding temperature	300–350° F.
Injection molding pressure	10,000–30,000 lb./in.²
Compression molding temperature	250–350° F.
Compression molding pressure	250–5000 lb./in.²
Mold shrinkage (injection molded)	.008–.012 in./in.
Specific gravity	1.68–1.75
Refractive index n_D	1.61
Tensile strength	4000–8000 lb./in.²
Elongation at yield point	15–25%
Modulus of elasticity tension	.7–2.0 $\times 10^5$ lb./in.²
Flexural strength	15,000–17,000 lb./in.²
Compressive strength at yield point	7500–8500 lb./in.²
Impact strength, $\frac{1}{2}'' \times \frac{1}{2}''$ notched bar, Izod	2–8 ft.-lb./in.
Thermal conductivity	2.2 $\times 10^{-4}$ cal./sec./cm.²/-° C./cm.
Specific heat	.32 cal./° C./gm.
Thermal expansion	15.8 $\times 10^{-5}$/° C.
Resistance to heat (continuous)	170° F., approximately
Resistance to heat (intermittent)	212° F.
Softening point	240–280° F.
Distortion point	150–180° F.
Volume resistivity (50% relative humidity and 25°C.)	10^{14}–10^{16} ohm-cm.
Breakdown voltage, 60 cycles, instantaneous	
.125" thickness	500 volts/mil
.020" thickness	1500 volts/mil
.001" thickness	3000 volts/mil
Dielectric constant	
60, 10^3 and 10^6 cycles	3–5
Power factor	
60, 10^3 and 10^6 cycles	.03–.15
Water absorption, A.S.T.M., D570–40T	Less than 0.1%
Burning rate	Self extinguishing
Effect of age	None
Effect of sunlight	Darkens slightly
Effect of acids, alkalies, solvents	None to slight
Effect of metal inserts	Inert
Machining qualities	Good
Welding ability	Unexcelled
Clarity	Translucent to opaque
Color possibilities	Extensive
Hardness:	
Rockwell superficial	15Y, 65–95
Durometer A	Above 95
Rockwell M	50–65

The water resistance of the material is excellent. On complete immersion molded parts absorb less than 0.1 percent of moisture. Its permeability to water vapor is very low and compares most favorably with all other thermoplastic materials.

Much has been said concerning the unusually high tensile strength of injection-molded saran. This is true of the material only in those sections which lend themselves to complete orientation. These sections are of uniform cross section such as are fabricated by extrusion and may be stretched and reduced in cross section during the orienting operation. This type of treatment is not feasible with injection molded parts, and so tensile strength values of the order possible with extruded and oriented sections are not realized. Actual tensile strengths obtained by injection are in the order of from 4000 lb. to 8000 lb. per square inch.

Molded parts show little tendency to contain sinks and shrink marks in heavy sections, since recrystallization occurs in the mold and because the injection pressure is transmitted to the casting after cavities are filled. Parts of thin wall sections can be fabricated if not too large because of the low viscosity of the material at molding temperatures.

A complete table of these and other properties of the material is shown in Table II.

This type of saran is not recommended for uses involving resistance to high speed impact, shock resistance of flexibility at sub-freezing temperatures, nor for applications requiring continuous exposure to temperatures in excess of 170° F.

The electrical properties of this new material are of a high order in molded section. These properties, along with its nonburning characteristic and the remarkable resistance to continued flexing which it possesses, its resistance to oils, fats, solvents and chemicals, and its unusually good degree of heat resistance, indicate the use of saran in many electrical and industrial applications.

Thermosetting compounds

(Continued from page 90)

Laminating

Because Columbia resins cure without evolution of any volatile by-products, and because they exist as liquids of low viscosity which have high penetrating power, thus requiring no solvents or diluents, these resins offer unique possibilities in the field of laminating. Base materials such as fabrics, felts, papers and wood can be saturated with the monomer containing a suitable catalyst and cured into laminated board by moderate heating with the application of no more pressure than is required to hold the layers in intimate contact with each other. This pressure ranges from 0.01 to 10.0 p.s.i., but for most applications is between 1 and 2 lb. per square inch.

Because these resins are transparent, substantially colorless, and highly resistant to wear, abrasion and attack by chemicals and weather, they are believed to offer interesting possibilities in decorative laminates. It is clear, however, that the monomeric liquid nature of these materials will necessitate the development of special methods for their use,

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TABLE II.—PROPERTIES OF C.R. 39 LAMINATES

	Fabric base	*Glass cloth base*
Specific gravity	*1.36	*1.73
Percentage of resin	*64	*50
Coefficient of thermal expansion, in./° C. × 10^{-6}:		
−38° C. to +50° C.	*4.2	...
50 to 70	*2.5	...
70 to 90	*3.0	...
90 to 110	*2.4	...
−31 to −18	...	*2.3
−18 to 0	...	*1.7
0 to 25	...	*1.9
Impact strength, ft.-lb./in., Izod, notched:		
−55° C.	*2.0	23.0 (25° C.)
+50° C.	*3.5	
+70° C.	*4.3	
Tensile strength:		
Ultimate	*7500 p.s.i.	*30,400 p.s.i.
Elongation at ult	4%	...
Tangent proportional limit .01% offset	*1800 p.s.i.	*3600 p.s.i.
Yield strength .2% offset	...	12,700 p.s.i.
Modulus of elasticity	*550,000	*1,700,000
Weathering 200 hr	*No surface defects	*No surface defects
Burning rate	1/8" thick, *.5"/min. 1/16" thick, *.7"/min.	1/16" thick, *.9"/min.

* Indicates tests made in independent laboratories.

different from those employed in working with conventional laminating varnishes, which are solutions of more or less solid resinoids.

Fabrics can be impregnated by simply brushing the monomer, either to successive layers as they are piled up or onto the assembled laminate of several thicknesses. The principal precaution to be observed is the elimination of air bubbles as completely as possible from all interfaces. Flat laminated sheets can be cured between plates of glass, metal or plastic with no more pressure than the weight of the top plate. Curved shapes can be made either by bending flat laminates according to the technique employed in shaping clear sheets, or by curing the original laminate in the desired shape. The latter method is preferable, if form stability is required and if no means is available for restraining the slight tendency of bent sheets to spring back to their original flat form.

For laminating shaped objects, inexpensive molds of plaster, papier mâché, cardboard, sheet metal, concrete, cast metal, wood, glass or combinations thereof can be used. The slight pressure needed to hold the plies in intimate contact with one another can be applied by screw clamping, wrapping tightly with dry fabrics, applying bags filled with shot as weights, by wrapping the cellophane-covered laminate with rubber tape under slight tension, by use of rubber bags either inside a female form and inflated to a few pounds per square inch or as envelopes around a male form and evacuated so as to utilize atmospheric pressure on the laminate, or by clamping together two rigid mold parts, one of which is cushioned by sponge rubber or some other means. Best results are obtained when one of the mold walls is rigid and the other flexible to allow for irregularities in section, overlapping of the fabric layers, etc.

Fully cured laminated sheets can be cemented together by use of the monomeric resin if the areas to be bonded are thoroughly roughened. A second heat treatment is necessary to cure the bonding monomer, but this has no apparent deleterious effect on the rest of the laminate. Reheating is usually carried out in an oven.

The properties of the finally cured products depend largely upon the nature of the base material used and cannot be stated generally. With paper and fabrics, however, Columbia resins give more flexible, less brittle laminates than do either phenol-formaldehyde or urea-formaldehyde resins. Some of the properties of certain more or less typical laminates are shown in Table II.

Hydrolized lignocellulose

(*Continued from page 97*) mold used (positive, semi-positive or flash), method of closing the mold, temperature of molding, flow of compound, method of measuring or estimating degree of cure, etc., all interfere with such a determination.

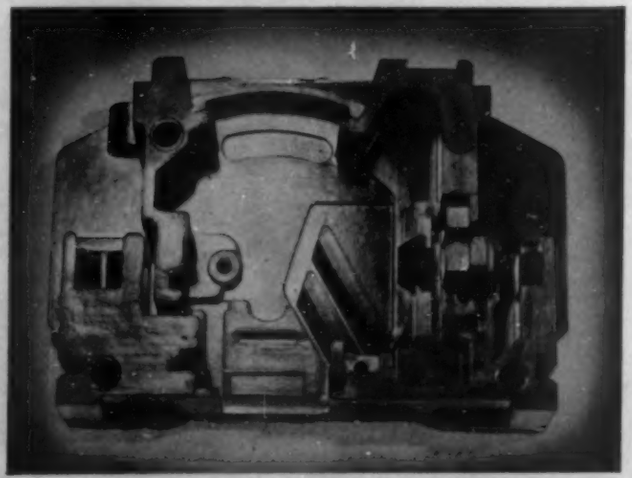
Tests in several molding plants on production presses and molds have been run recently on phenolic molding compounds filled with 75 percent of hydrolyzed lignocellulose. Although run on a variety of molded articles under varying production conditions, all indicate that this new molding compound cures in 30 to 50 percent less time than the standard woodflour or cotton-flock filled compounds used for the same jobs. The molded articles may be removed at molding temperature without warping, blistering or causing damage to the mold surface.

Conclusions

Improvements in the properties of hydrolyzed lignocellulose due to the continuous process have resulted in the formulation of molding compounds containing 1 part of phenolic resin to 3 parts of hydrolyzed lignocellulose. Thus, it is possible during the present national emergency to increase greatly the amount of plastics which can be made from the limited supplies of phenolic resins which are available. These compounds have properties desired in general-purpose molding powders and have been found acceptable by the molding trade. Small quantities from pilot plant operation are now being utilized in production molding.

Although some of the physical properties are in the low ranges of desired values, all are acceptable for general-purpose molding. Plasticity may be rated according to accepted

19—*Electrical connector molded from plastics filled with hydrolized lignocellulose. Note detail and depth of molding*



Plastics are no longer just attractive inkstands, buttons and gadgets to hang on a lady's coat lapel. Now they play an important part in war production. Plastics are taking the places of innumerable metal parts and in many instances are doing the required job better. But with these new uses come new responsibilities. The plastics you produce must meet exacting standards as to strength, form, and color. This means the accurate following of prescribed temperatures in curing. Powder manufacturers have long recommended the use of the Cambridge Pyrometer for accurate and convenient temperature checking. While the use of this instrument was desirable, before the war, today it is indispensable.

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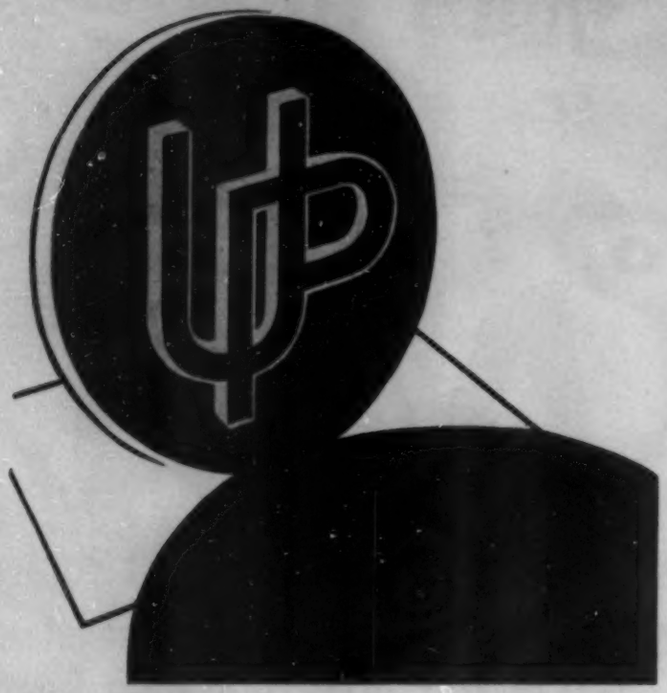

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20—*Phonograph pickup arm of hydrolized lignocellulose*

practice as medium to medium hard. Further improvements in plasticity and other physical properties may be anticipated when resin manufacturers produce phenolic resins formulated specifically for use with hydrolyzed lignocellulose.

By substituting continuously-hydrolyzed lignocellulose for woodflour in the same proportions as are commonly used (e.g., 45 to 50 percent filler) compounds having an exceptionally high resistance to moisture are obtained.

The experimental data presented establish the fact that hydrolyzed lignocellulose is not simply an inert filler, but it is reactive in the polymerization-condensation reactions encountered during the thermosetting process. Work which has not yet been published has resulted in the isolation of the fractions of hydrolyzed lignocellulose which are responsible for this interaction. The reactivity of these fractions accounts for the acceleration of compounding and molding operations, as well as for the adverse effects of excessive catalyst in the compound.

The new semiplastic filler described is readily manufactured from waste materials in simple equipment, and is utilized by the compounder and molder according to standard procedures now in use.

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[7] Kline, G. M., MODERN PLASTICS *18*, Oct. 1940, p. 119.
[8] Plastics Catalog, p. 157 (1942).
[9] Rosenthal, F., *Ind. Eng. Chem. 33*, 980 (1941).

Seeing is believing

(*Continued from page 58*) screen is said to produce a cold light because of the fact that the crystals on the screen will split each light ray passing through into as many rays from center to edge as is desirable for optimum reproduction. The result is described as clearly defined images, no grain and a picture unaffected by leak light from the camera side. Brilliancy and sharp definition of the picture are achieved in the finishing process, which consists of applications of crystals to

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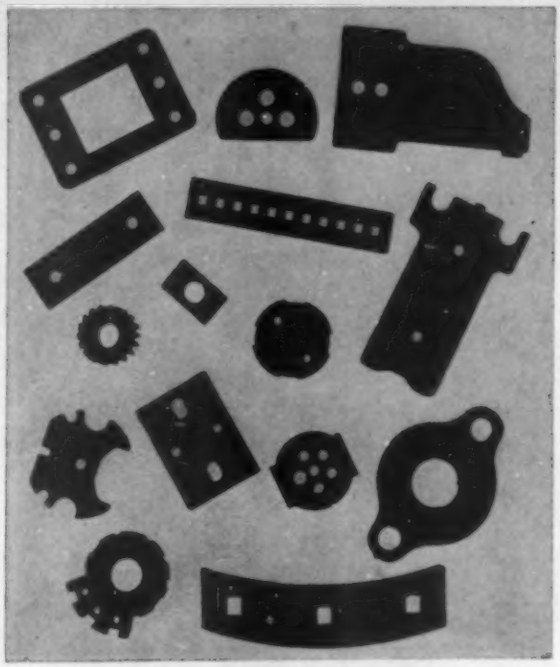

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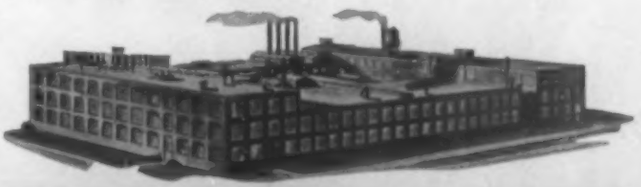

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give a polarized effect. This polarization process makes it possible for the screen to withstand a tremendous amount of foreground lighting without "washing out" the picture, or diminishing its clarity. Precision balance of the screens is essential as they serve as a "secondary camera lens."

Different types of screen are also available from this material for incandescent or carbon projections, these coming in black, white and in colors. Sizes range up to 45 by 75 feet.

Aside from its primary use for background projections for composite shots, both in still and motion-picture photography, the screen is also being used for television projection, advertising displays when used in connection with a continuous slide or film projector, and for backgrounds for table top and miniature photography. In 16-mm. juke boxes and motion pictures for entertainment purposes, especially made screens give a definite illusion of depth, with a very nice picture when viewed from all angles.

Not only has the use of this screen and the composite technique succeeded in saving thousands of dollars in materials, but time, effort and travel have been and are being conserved in goodly quantities.

Credits—Material: Hercules ethyl cellulose. Safti-Cellulose Flat Light Screens by Plas-Tex Corp. Invented by Bernard M. Bodde

Insulation aboard vessels

(*Continued from page 49*) types of electrical and mechanical instruments. Even further, a large proportion of all electrical instrument and mechanical gage cases, some thermometers, etc., now utilize plastics in lieu of metal. If one tried to list all plastic applications by name or part number or drawing number, the list would run well into the hundreds of thousands.

1942: today and tomorrow

Obviously this discussion will have to conclude without any too detailed or exact information as to what is actually being done now or contemplated for the future, other than that which may be found in the various Navy specifications. That can best be told some years from now. It might, however, be well to emphasize again the necessity for avoiding too many preconceived notions or glib explanations about plastics which sound like news. Synthetic plastics were born in a test tube. They should grow up in the same atmosphere and not in the public press or on a platform. Testing and still more testing and an open mind are the essentials of further progress. It might be stated, however, that the question of whether or not a Navy application is yearning for a plastic falls into one of the three following categories:

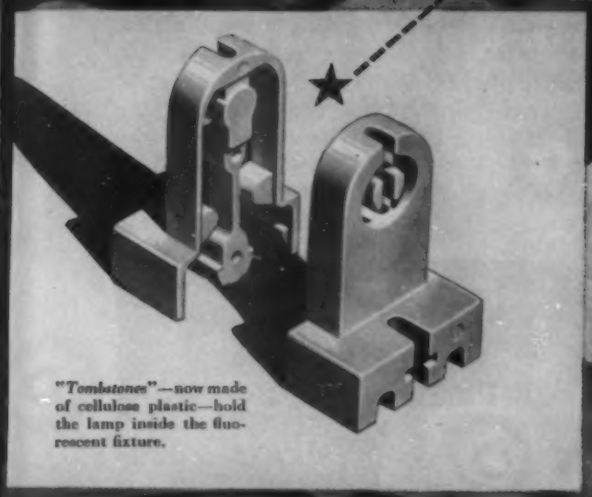
(a) Where the plastic can do a better job than anything else.

(b) Where critical materials have been thought necessary but where a noncritical plastic might serve as a temporary expedient (*ersatz*). It might not necessarily do a better job or even so good a one as that done by the material originally used, but still might answer for the duration.

(c) Finally, those applications where a plastic does not at present seem to have any immediate possibility of satisfactory use; or where a considerable time might be required to develop it; or where its use might even necessitate re-design of equipment to adapt it to the poorer material. This field should be left untouched until (a) and (b) have been exhausted.

(*Please turn to next page*)

"Tombstones" get a tough plastic



"*Tombstones*"—now made of cellulose plastic—hold the lamp inside the fluorescent fixture.

Electrical parts of Celanese Celluloid Corp. LUMARITH, based on Hercules Cellulose Acetate Flake

Add this to the many properties of cellulose acetate plastic: *dielectric strength*. The holders for fluorescent lamps—nicknamed "tombstone" fixtures—are now, with approval of Underwriters' Laboratories, molded from this tough and versatile material.

DESIGNERS TURN NOW to cellulose acetate not only for fixtures, but for coil core housings, cap plugs, bobbins for motors, and a long list of other electrical parts. Thus the inherent toughness, the stability, the swift and economical processing of cellulose plastics go to another whole industry's aid.

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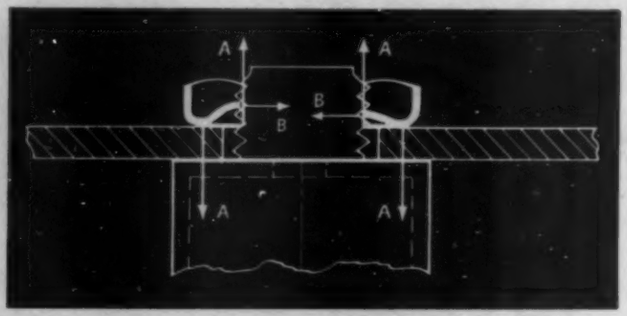
Finally I want to emphasize that nothing referred to in this article is the result of any so-called recent drive. It is long-established practice—a permanent drive. The principles on which these engineering practices are based were not started as a result of this war. They are merely the technical framework within which the present streamlining can be accomplished in the most simple, rapid and effective manner known and possible to us.

Assembly device

(*Continued from page 78*) the first plastics applications for this lock nut; but during the last few weeks development for this type of work has been underway, aiming at the general use of this lock nut for all lug assembly applications using thermoplastic material. Because this lock nut uses a thin section thread, as shown in the illustrations, it has the same action as a threading die. It cuts its own thread on a lug of the proper diameter, and when screwed home the steel jaws close deeper into the lug, acting as a positive vibration-proof lock.

The development work, when completed, should yield the necessary data for designing for this lock nut. An example is



5—Arrows A-A and B-B show the two stresses acting at right angles to each other which are brought into play by the double-locking action of the locknut assembly device

that for a standard $^1/_4$ in.–20 lock nut of this new type, a thermoplastic lug .225 in. in diameter with about a $^1/_8$-in. long starting taper should be employed. These assembly lugs can generally be molded integral with the molded part, but they also can be easily welded on the molded part by the use of the proper solvent for the type of thermoplastic material used.

Separate assembly lugs may be easily molded by adding a few inexpensive cavities to an existing mold, or may be cheaply turned out from standard rod, either on a small lathe or a small screw machine.

Credit: Palnut, manufactured by Palnut Co., Inc.

S.P.E. convention

(*Continued from page 57*) Calcutta and patrol the fog-bound coasts of the Aleutians. And to all these fighting men, wherever they may be, must go an uninterrupted stream of materials for war—guns, ammunition, tanks and planes, warm clothing and medical supplies and good food, mail and mortars and motor trucks. These and all the other multitudinous military supplies, together with reinforcements and replacements of the men themselves, *must get through*.

To see that they do get through, the Navy must maintain

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There will be many new articles on Synthetic Rubbers, the History of Plastics, and other vital subjects. There will be lists of every Government Department and Bureau having any procurement relationship with the plastics industry, enabling plastics manufacturers to get directly in touch with the proper office in each.

Each year, in spite of ever larger printings, the Plastics Catalog has been sold out soon after publication. This year, production problems are more difficult than ever before and the demands are greater.

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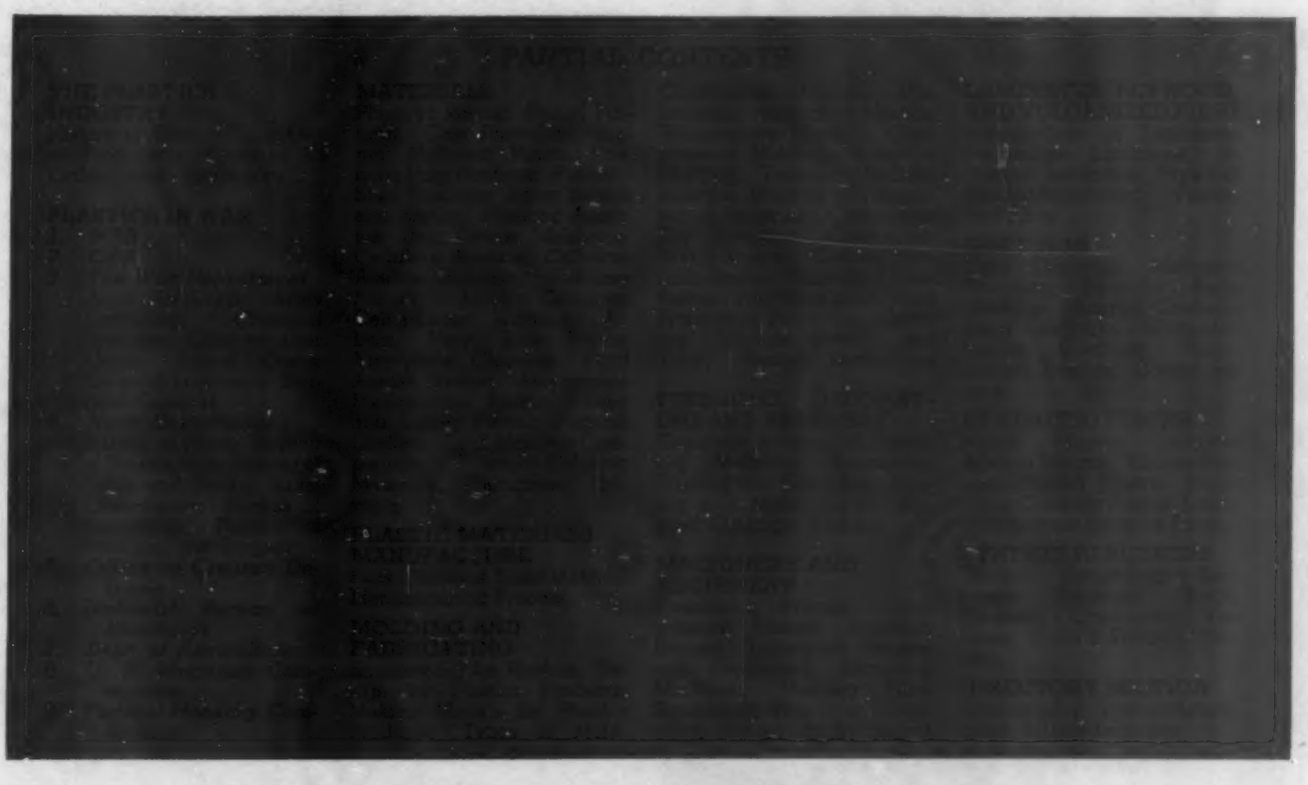

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the longest and most hazardous lines of supply ever attempted by any warring nation. The distance from New York to Iceland is 3000 stormswept miles, plus 3000 more for the return trip. Between here and Ireland, where the largest convoys in American history have already landed, are 3300 miles of periscope-pocked ocean. The tortuous route to Russia covers more than 5000 sometimes very rough sea miles. Australia: 7700 miles from San Francisco, at least 11,000 from New York. India, where enormous U. S. forces have arrived, well over 10,000 miles via the Cape of Good Hope. Add to these distances the trips to Hawaii, to Samoa, to the Solomons, to the Aleutians, and you will get some idea of the tens of thousands of miles of ocean routes we must control and protect if we are to win this war.

We have been particularly fortunate in getting our troop transports through without loss of life. But a small amount of war material has been lost on troop convoy. Maintaining a ceaseless, monotonous, nerve-wracking vigil on the sea and over it, in all kinds of weather and at all seasons of the year, the Navy's job is to land them safely!

The Navy is bending every available ounce of energy to winning the U-boat war in our own waters. It is rushing to completion a vast fleet of sub-chasers and other patrol craft, numbering not scores but hundreds upon hundreds—a mighty Armada of sleek, speedy, deadly little vessels. The air patrol is being doubled and redoubled, too. Planes of all kinds, large and small, and blimps as well. The day is not far off when Nazi submarine commanders will be afraid to sail in this hemisphere.

My present duty in the Navy is planning and initiating the installation of all ordnance equipment on naval auxiliaries and all merchant ships. This work, which cannot be underestimated in its importance, lies right at the crux of winning this war, if our fleet and Army are to be supplied with ammunition, food and all the other necessities. Nevertheless, very shortly, I expect to be in charge of a Plastics Section in the Bureau of Ordnance. And I will need the help and assistance of every technician, every manufacturer and every plastics expert in the industry when I take over my new job.

Plastics, as I mentioned at the beginning of this paper, are not new to the naval service, but a great deal of research and development work is now proceeding to find new items of naval ordnance which may be made from plastics to replace critical metals, or to fit the job better than any other material.

Between the Navy's fighting material on the one hand—guns, ammunition, bombs, depth charges, torpedoes—and these new substances invented by chemists on the other hand—laminated phenolics, cellulose esters, methyl methacrylate—there is a close relation, a material relation about which it gives me pleasure to devote part of my address this evening.

The plastics industry occupies a new and unique position in the streamline of procurement of naval ordnance. By this I do not mean that steel forgings for armor-piercing projectiles, or gun barrels or breech housings can be made from plastics—but I do mean that plastics are now being employed where even a year ago such use was considered by many to be impossible. And these plastics of which I speak are doing a very satisfactory job. Not only that, but they are releasing metals on the critical list, saving many, many tons of aluminum and copper, saving man-hours of skilled mechanics which are made available for other war work. And the use of plastics has increased output. Speed of production of fighting equipment, as you all know, is essential to our victory! Plastics are on the job for the Navy and they are doing an

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Many farsighted manufacturers, however, are preparing NOW for postwar products and markets. And well they should . . . for industrial progress resulting from the war may cause revolutionary changes in postwar products, and buying habits. Plastics are sure to play an important part in these changes. Consult our competent plastics engineers. Possibly SINKO Precision Injection Moldings may be just what you need for that new product you plan to market when peace has been declared.

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excellent job, but much more research and development work remains to be done. To investigate, to explore, to test this and that plastic composition for Naval Ordnance use—that is going to be my job. The field is great. The Navy's tests are rigid and practical, for our men and our ships must have the best, and they are getting it. It is imperative that bombs, ammunition and torpedoes function without fault. Think how disastrous it would be if a dive bomber were to drop a "stick of bombs" on an enemy carrier, or a torpedo were to hit its target without a "high order" detonation.

A few moments ago I referred to smokeless powder. Cannon powder is a pure nitrocellulose plastic extruded through a die under great pressure, having previously been colloided with ether and alcohol or acetone and mixed with small quantities of other ingredients. Many years ago I was the chief inspector of one of the Government's largest powder and high explosive plants and it was there that I had some of my first plastics experience. I found, for instance, that the decomposition of this plastic substance could be practically instantaneous, as I was blown bodily out of a door when a heavy calibre powder line press "let go."

During World War I, I was assistant naval inspector of powder and explosives.

Between wars, as an industrial consultant chemist and engineer, I have had an opportunity for research on several plastic materials such as structural compositions for building purposes, various thermosetting resins, synthetic glues, lignin, indene, phthalic anhydride and other resins. One of my earliest patents was on a fiber, tannin-silicate plastic board composition. Synthetic tannins may be described as a special class of water-soluble plastics.

For reasons of security I am unable to describe many of the important uses of plastic materials in naval ordnance. I can, however, give you the following list of successful applications, which is not a complete one by any means:

Fuze covers	Instrument disks and parts
Tampions	Instrument housings
Bayonet scabbards	Fire control terminal blocks
Dummy bayonets	Signal grenades
Machete scabbards	Booster tubes
Signal pistols	Fuze plugs
Fire control panels	Non-corrosive coatings

And many other uses or prospective uses about which I am not able to talk.

Realizing that you know that most of my research on plastics has been carried out in my laboratories in England, I presume there are some in the audience who would like to know what differences exist between American and British plastics and methods. To those I would say that the development in Britain has followed pretty much the same trend as that in our own country. As there is no cheap supply of calcium carbide in England, the production and development of the hydrocarbon plastics have suffered there. Also there is little development going on in Britain with the lignin plastics due to the fact that even in times of peace there are only two sulfite pulp mills in the country. I am assuming that the "black liquor" from the sulfate, monosulfite and soda processes would not be economical to work for plastics, although its value some day for plastics might exceed its soda recovery and fuel assets.

Some very good ketone plastics have been produced experimentally in England and a good deal of research has been conducted with various ketonic substances and their condensations with benzene derivatives.

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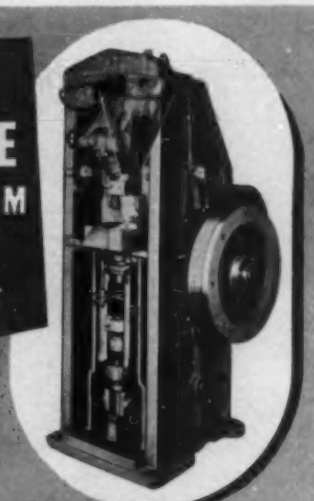

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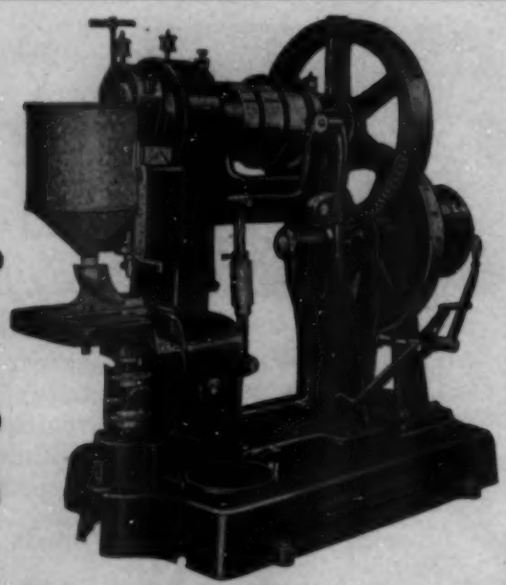

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ton (British Government operated) are a great encouragement to the development of plastics. I have had two of these Government chemists cooperating with me at my own laboratories in Hertfordshire.

As I mentioned previously, the Navy needs the help and practical assistance of every company in the plastics industry to make the winning of this war easier. You have already assisted your Navy in no small degree and we are counting on you all to cooperate to the fullest possible extent. I know you will continue your fine support. And I can assure you that in these difficult days your Navy, wherever its operations extend, whether at sea, in the far corners of the earth or ashore in production and research, will carry out those operations with the gallantry, the thoroughness and the indomitable fighting spirit that are its tradition. You can be sure, also, that however long and difficult the course to ultimate victory, your Navy will pursue it with vigor and intensity until the very end.

Mr. Thomas Carswell, director of research, Plastics Division, Monsanto Chemical Co., then gave a talk, illustrated by slides, on the properties of various thermosetting resins. Contrasting them with thermoplastic resins, he pointed out the distinctions among materials having different fillers.

President Conley announced the formation of a Technical Committee under the chairmanship of William B. Hoey, Bakelite Corp. Mr. Hoey outlined his hopes for the future of technical work to be done by the society, and discussed briefly the reasons for the creation of S.P.E.

"This organization," he said, "has tremendous possibilities. It could be to the plastics industry what the Society of Automotive Engineers is to the automotive industry and what the American Chemical Society is to the chemical industry and what the Institute of Radio Engineers is to radio. It could be a forum for collecting and disseminating technical information in the same manner as the other national engineering societies.

"If enough of the men of the various cities can see the possibilities that I see," Mr. Hoey concluded, "this Society of Plastics Engineers can be a real national engineering society with all the benefits which other engineering societies bestow upon their membership."

Machining acrylics

(*Continued from page 76*) shops specializing in the machining of plastics and, as most of the same machines are available also in shops devoted chiefly to working metal or wood, such shops often extend their work to include the working of the acrylic or other thermoplastics which are available in rods, sheets, tubes and extruded shapes. The technique of cutting plastics is far from difficult and is quickly learned by those familiar with wood and metal work. Even novices in such work have quickly learned to machine plastics, as they have had to do in the aircraft industry, for example, where there is not a sufficient supply of skilled labor to meet requirements.

It is probable that there are today more people engaged in the working of plastics than ever before. There seems to be little doubt that the familiarity with plastics gained by this growing group of workers will have a favorable effect in still further extending the use of plastics after the war.

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American Chemical Society

(Continued from page 98)

ISOLATION AND IDENTIFICATION OF THE RESINOUS BINDER IN WATER PAINTS. Robert W. Stafford, Stamford Research Laboratories, American Cyanamid Co., Stamford, Conn.

An analytical procedure for the isolation and identification of the resinous binders used in water-emulsion paints is outlined and discussed. Three general methods for the separation of the binder are recommended for use either separately or together. The determination of characteristic physical and chemical properties is outlined. Particular emphasis is placed on the analysis of alkyd and rosin type resins. A procedure is given for the separation of an alkyd resin into its dibasic acids, polyhydric alcohols and modifiers, and methods are suggested for identifying most of the probable members of each group. Rosin resins are included in some detail. A suggested method for the detection of rosin adducts by ultraviolet spectroscopy is outlined.

THE DIP COATER, AN INSTRUMENT FOR MAKING UNIFORM FILMS BY THE DIP METHOD. Henry Fleming Payne, American Cyanamid Co., Stamford, Conn.

A relatively simple machine has been developed to apply a surface coating film of uniform thickness to a panel by withdrawing the panel at a constant speed from a tank containing the coating material. Data have been obtained showing the variation of film thickness and uniformity of thickness on a panel 12 inches long, with rate of withdrawal and physical characteristics of a variety of coating materials. Details of construction of the dip coater will be presented, but arrangements have been made for the commercial production of the apparatus, so that a standard method of dip coating test panels will be readily available to the surface coating industry.

The following papers were presented before other divisional meetings of the American Chemical Society.

MODERN PLASTICS AND E.S.M.D.T. AT PENNSYLVANIA STATE COLLEGE. J. W. Richardson and Arthur Rose, The Pennsylvania State College Extension Services, State College, Pa.

This paper traces the development of an E.S.M.D.T. course entitled "Production, Properties and Utilization of Plastics" from the initial requests from industries to the actual class and laboratory instruction. The classwork in this course is based to a large extent upon the chemistry involved in the production of plastics, with considerable emphasis on properties, uses and production operations. One hundred hours of instruction were given, about half of which was laboratory work. The laboratory work includes the preparation of a number of the more important resins, study of their properties, and some experience in actual molding of plastic pieces. Seven different classes have been offered with regular E.S.M.D.T. extension facilities in four different towns in Pennsylvania with a total student population of 230. The paper outlines the major topics considered in class and laboratory work, discusses the qualifications of instructors and students, and emphasizes the variation in instruction to meet specific industrial needs.

COAL AS A SOURCE MATERIAL FOR THE PLASTICS INDUSTRY. Reginald L. Wakeman, Mellon Institute, and B. H. Weil, Gulf Research and Development Co.

An estimated 360,000,000 pounds of synthetic resins, exclusive of cellulose derivatives, were produced in 1941 as compared with

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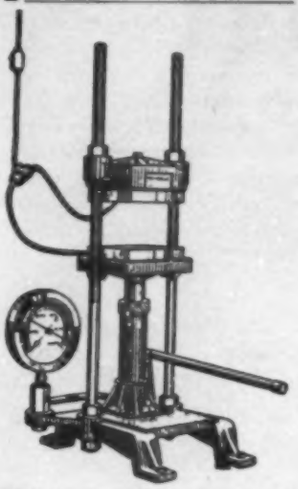

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only 13,450,000 pounds in 1927. As late as 1940, however, plastics output was still less than 0.5 percent of steel production. Coal has long been the chief source for plastics intermediates, basic materials being (1) light oil and coal tar, (2) water gas, and (3) coke itself. Some 7 percent of the benzene produced, 80 percent of the tar acids (natural and synthetic), 66 percent of the naphthalene, and all of the coumarone-indene from light oil and coal tar went into 1941 production of phenolics, nylon, polystyrene, alkyds, and coumarone-indene resins. Of 1941 formaldehyde production, close to 75 percent was consumed by such resins as the phenolics, ureas and melamines. Intermediates for methyl cellulose and the methacrylates were also produced from water gas. Acetylene from calcium carbide is a source for numerous thermoplastics, although coal competes with petroleum hydrocarbons in this field. Both acrylonitrile for synthetic rubber and melamine are produced from coke through calcium cyanamide. While petroleum derivatives, agricultural products and natural resins will provide keen competition, a sound program of research should enable coal to play a vital role in the future expansion of the plastics industry.

THE POLYMERIZATION OF PHENOXYACETYLENE. William Penn Tuttle, Jr., and Thomas L. Jacobs, University of California, Los Angeles.

Phenoxyacetylene polymerizes rapidly, finally yielding a black solid. A brown powder with the empirical composition of monomer was isolated by precipitation or by removing low molecular weight materials by extraction. Half of the phenoxyl groups were lost as phenol by heating this polymer at 1 mm. and 30 percent of those remaining were removed by alkali fusion. Therefore the polymerization cannot involve ring substitution. The rate of polymerization is not influenced by benzoyl peroxide, phenyl-α-naphthylamine, p-toluenesulfonic acid or other substances. Alkoxyacetylenes polymerize less readily than phenoxyacetylene, while Chalmers has shown that alkyl vinyl ethers polymerize more readily than aryl vinyl ethers.

The polymerization of phenoxyacetylene proceeds in two steps, the first leading to a red substance whose absorption spectrum has a maximum at 4200 Å. This material is believed to be a conjugated linear polyene. It gives a blue color with antimony trichloride and behaves like a highly polar ethylene giving brilliant colors with bromine or strong acids. On standing, the solution becomes colorless and no longer gives the color reactions. This change results from cross-linking which may proceed by a Diels-Alder reaction. Polymers obtained at higher temperatures give intermediate absorption curves and may be separated into polyene and cross-linked polymer by chromatographic adsorption.

Phenoxyacetylene polymers readily lose phenol on heating or standing in solution. This occurs after cross-linking and is believed to be due to the aromatization of the cyclohexene rings formed during that process. This accounts for the ready elimination of 50 percent of the phenoxyl groups, those that remain being substituents on the aromatic system. Intermediate polymers are thermosetting plastics and heat treatment or long-continued polymerization produces infusible, insoluble substances which are very brittle and undoubtedly highly cross-linked.

ANOMALOUS VISCOSITY OF ORGANIC HIGH POLYMERS. Elmer O. Kraemer, Biochemical Research Foundation, Newark, Del.

When reference is made to the anomalous viscous behavior of organic high polymers, it is commonly considered that normal or, better, "ideal" behavior is that displayed by dilute suspensions of small, uncharged, rigid, inert spheres in a normal liquid, in which there is no tendency to aggregation. Very few organic high polymers (namely, some of the proteins) approximate this behavior; most of them depart in one or more respects

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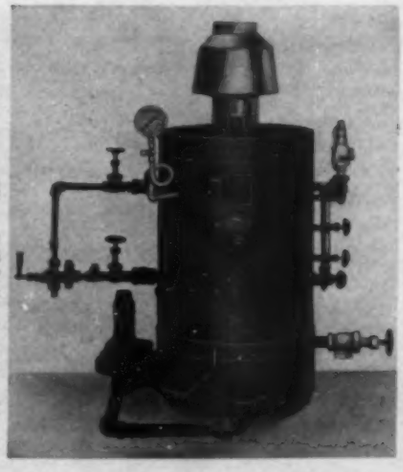

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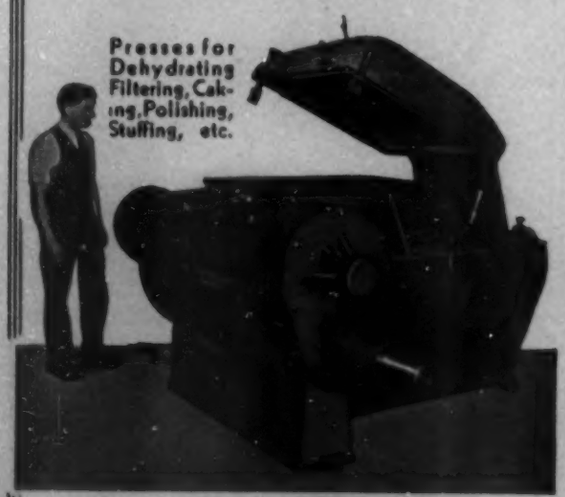

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from this ideal viscous behavior. Anomalous viscosity manifests itself in the form of

1. Variable consistency with change in shearing stress.
2. Values of intrinsic viscosity substantially in excess of .025.
3. Variation of intrinsic viscosity with solvent.
4. Temperature coefficient of intrinsic viscosity not equal to 1.
5. Exceptionally rapid increase in viscosity with increasing concentration.
6. Elastic phenomena.
7. Dependence of viscosity on thermal or mechanical history.
8. Sensitivity of viscosity to presence of ions.

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5. Adsorption of medium or solvation.
6. Reversible or irreversible gelatin.
7. Associative or aggregative interparticle forces.
8. Coulomb forces and interparticle action due to electric double layers.
9. Slippage of liquid on particle due to incomplete wetting.
10. Segregation of particles leading to plug-flow and wall effects.
11. Effect of temperature, pressure and concentration on any of the above factors.

Experimental data on organic high polymers are summarized and discussed from the above points of view.

KINETICS OF STYRENE POLYMERIZATION IN VARIOUS SOLVENTS. J. Abere, G. Goldfinger, H. Mark and H. Naidus, Brooklyn Polytechnic Institute, Brooklyn, N. Y.

The polymerization of styrene was studied in a series of organic solvents. It seemed of interest to carry out these reactions under similar conditions in order to enable us to make comparisons. Such comparisons are not easily possible on the basis of available experimental results, where various solvents were used by different investigators, and consequently slightly varying conditions. Besides other solvents, methanol was also used, which is a nonsolvent for polystyrene. The product of the polymerization, therefore, precipitated and gave additional opportunity to observe the course of the reactions. The polymerizations were carried out under a standardized condition at various temperatures and varying solvent-monomercatalyst ratios. The reactions were in general interrupted after only a fraction of the monomer had reacted. The absence of important quantities of polymerization products in the polymerizing solution minimized their secondary effect on the course of the reaction.

THE NATURE OF THE SECOND ORDER TRANSITION IN POLYSTYRENE. T. Alfrey, G. Goldfinger and H. Mark, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

Many organic glasses "soften" to viscous liquids in rather narrow temperature ranges. The transition differs from the melting of a crystal in that it is not accompanied by a discontinuity of volume, energy or entropy. There is often observed, however, a second-order transition in the neighborhood of the mechanical "softening point." Such a transition is characterized by a discontinuity in the first derivative thermodynamic variables; that is, an abrupt change of slope in the volume, energy and entropy curves versus temperature. In the case of amorphous high polymers, the corresponding transition is from a "glassy" to a "rubbery" state. In this investigation, the second-order transition for polystyrene was investigated, through observation of volume changes. *(Please turn to next page)*

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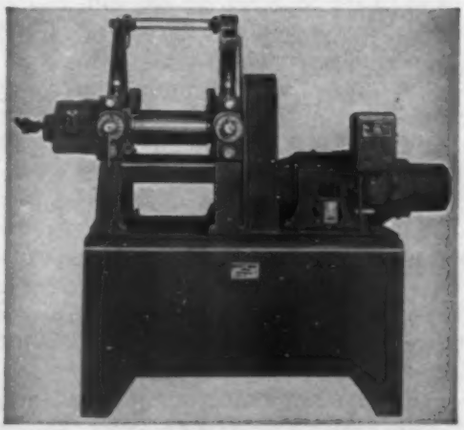

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The results indicate that the transition temperature does not indicate a true thermodynamic singularity, but represents the point at which the time necessary for the attainment of volume equilibrium becomes of the same order of magnitude as the investigational time scale. Since the flow response to a mechanical stress, thermal expansion and contraction of a liquid, and the change of enthalpy and entropy, all depend upon molecular diffusion, it is to be expected that the relaxation times of all these changes should be of the same order of magnitude at any temperature. Accordingly, the mechanical softening should occur at roughly the same temperature as the thermodynamical transition.

Booster tube

(*Continued from page 66*) tion will again be resumed.

It may appear unusual that a hardened and polished pin of this length can be bent several thousandths of an inch out of line and then bent back again without cracking or breaking. However, production has proved that this can be done.

As a matter of fact, if the force plugs cannot be straightened by the overloading method, because of their being bent out of line too badly, there is another method for bending them back to their original position without removing the mold from the press. This is done by means of a straightening device. However, the details of this ingenious fixture are not available for publication.

The overall length of this booster tube is also very important. Therefore, it can be seen that the finishing operation of sanding the nose of this tube performs two functions, namely, properly finishing the vent, and finishing the piece to the correct length. This is done by using a jig which holds the piece against a rotary sanding disk.

This tube is now being produced in quantity for Army Ordnance and is a prime example of the job that plastics are doing in the war effort.

Old light—new dark

(*Continued from page 64*) a motion picture theater after passing through the brightly lighted lobby, and has been obliged to stand still for a few seconds until simple objects become recognizable. Once the eyes become accustomed to them, lights of very low intensity seem quite bright.

In the half-dark—a moonlight night, for example—the phosphorescent pigments have no advantage over white because they appear almost white themselves; but at the point where white becomes gray and darker, or where it cannot be seen at all, the phosphorescent pigments glow and are clearly visible. The size and shape of the surface colored with phosphorescent pigments have a great deal to do with their visibility. The larger the luminescent area and the simpler the shape, the better the luminous highway sign can be seen. Phosphorescent letters and signs which have to be read at any distance should be as large as is practicable.

The initial brightness of most of the phosphorescent pigments is good, but that of the afterglow fades—in some rapidly, in others not for 12 hours or more. This seeming disadvantage is not so great when it is realized that the pigments can be easily and quickly recharged with light, and if this is done periodically, little or no loss will be noticed. Even a short exposure to an ordinary flashlight will produce a glow that lasts for some time. Usually, the pigments are kept in the light during the daytime so that they may be effective at night, or exposed to artificial light for an hour or longer;

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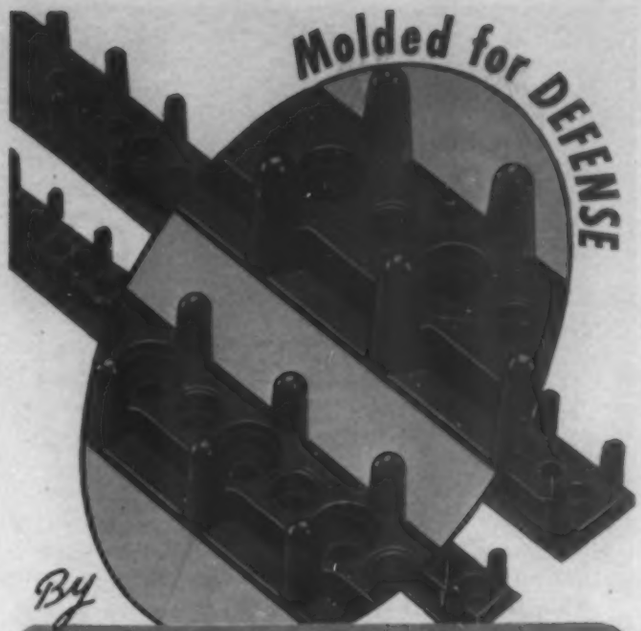

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this charge and discharge of light can go on as long as the pigment lasts.

Technically, these pigments are called phosphorous, but they must not be confused with the element phosphorus from which they differ chemically. The glow of phosphorus is due to oxidation, a kind of burning.

The first luminescent phenomena in chemical preparations was, as we have said, observed in the 17th century, when Casciarolus heated up mineral barium sulfate, thus producing a certain amount of alkaline earth sulfide—and was highly surprised when his material exhibited a glow in the darkness!

The first written report we have concerning "luminous minerals" is by La Galla, who in 1612 tells about a mineral which glows in the dark after being exposed to daylight. A detailed report was written by Poterius in 1625. The Italian physician Fortunius Licetus gives the year 1604 as the date of the discovery of this mineral.

In 1682 Christoph Adolph Vaduinus found another luminescent material, and in 1693 Homberg discovered a product which exhibited a glow when it was crushed. Nicolas Lemery, early in the 18th century, found that mixing certain metals with the luminous material has some influence on the color of the emitted light.

The luminous pigments are generally the carbonates of borates, silicates and especially the sulfides of such metals as zinc, cadmium and the alkaline earth group (calcium, magnesium, strontium and barium). These substances must be manufactured in a high grade of purity to get the best luminosity, though—paradoxically—when pure they exhibit no afterglow. The impurities, known as activators, are added. Typical activators are such metals as copper, silver and manganese, added in minute quantities before the mixture is brought for a period of time to red heat. The activators also influence the color of light which is emitted by the pigment. Other metals, on the other hand, act as poisons, and no metallic equipment can be used during the manufacture of the luminescent pigments.

All the pigments are in crystalline form and cannot be ground, for as soon as the crystal is crushed the pigments lose their phosphorescent properties. Since the pigments are subject to heat treatment in the manufacturing process, they can stand considerable heat and may be molded into plastics either by compression or by injection. The pressure of molding does not affect the pigments when they are mixed with the plastic molding powders. Powders should be made of transparent resins, pale in color, and should not contain other pigments, colors or fillers. Resins best suited to the manufacture of luminous plastics are the acrylates and methacrylates, the vinyls, cellulose acetate and polystyrene. The resin molding powder should be ground to 100 mesh before it is mixed with the luminous pigments.

Another method of making luminescent plastics is to mix the luminous pigments with the plastic material in the B state. If this is done, the plastics molder has nothing to do with the mixing and can buy luminous molding powders ready to be molded.

Luminous plastics in present use include dials, knobs, door handles, house numbers, signs, highway markers, jewelry, etc. Civilian defense authorities will undoubtedly find numerous applications for these materials as precautionary aids during blackouts, both indoors and out, on stationary objects and on persons and vehicles in motion. And soon the U. S. citizen will see nothing strange or unnatural in strips of eerie light edging his cellar stairs, a luminous disk dangling from his child's wrist, or a ghostly collar on the family dog.

CLASSIFIED

WANTED: THERMOPLASTIC MATERIALS of all descriptions—Scrap and Virgin. Please furnish full particulars and send small representative samples. It will pay you to consult us regarding custom grinding, demagnetizing, cleaning and grading of your materials. All inquiries will receive prompt and careful attention. H. Muehlstein & Co., Inc., 122 East 42nd Street, New York, N. Y.

WANTED: PLASTIC SCRAP OR REJECTS in any form, Cellulose Acetate, Butyrate, Polystyrene, Acrylic, Vinyl Resin, etc. Also wanted surplus lots of phenolic and urea molding materials. Custom grinding and magnetizing. Reply Box 318, Modern Plastics.

FOR SALE: 1—W.S. Hydro-Pneumatic Accumulator 2300 PSI, 8 gal., with IR m.d. compressor; 1—Hydro-Pneumatic Accumulator, 2500 PSI, 16½ gals., complete with tank, compressor and piping; 1—W.S. 15″ x 18″ Hydraulic Press, 10″ dia. ram, 4′ posts; 1—Triplex Hydraulic Pump, 11 g.p.m. at 2000# pressure, also others; 1—W.S. Hand Pump; 1—set of Compounding Rolls 18″ x 44″; Adamson 6′ Tuber; 7—W. & P. Mixers; Dry Mixers, Pulverizers, Grinders, etc. Send for complete list. Reply Box 446, Modern Plastics.

WANTED: THERMOPLASTIC SCRAP or rejects in any form, including Acetate, Butyrate, Styrene, Acrylic and Vinyl Resin materials. Submit samples and details of quantities, grades and colors for our quotation—Reply Box 508, Modern Plastics.

WANTED: Hydraulic Presses, Preform Machine and Mixer, Stainless Steel or Nickel Kettles, Vacuum Pan. No Dealers. Reply Box 275, Modern Plastics.

FOR SALE: 350 Ton Hydraulic Lead Wire Extrusion Press with Pump. 400 Ton horizontal Hydraulic Extrusion Press. Hydraulic Scrap Baler, 80 Ton, 6½″ Ram, 90″ stroke, 5000 lbs. per sq. in. Three J. H. Day #30 Imperial Mixers, double Sigma Blades, two steam jacketed. 75 ft. link belt conveyor, 36″ wide. Large stocks of Hydraulic presses, pumps and accumulators, preform machines, rotary cutters, mixers, grinders, pulverizers, tumbling barrels, gas boiler, etc. Send for bulletins #138 and L-17. We also buy your surplus machinery for cash. Reply Box 439, Modern Plastics.

FOR SALE: Southwark 225 ton Inverted Ram Hydraulic Press with pushbacks and ejectors. Reply Box 512, Modern Plastics.

FOR SALE: One Electrically operated and heated plastic Dryer of the conveyor type, overall size 7 x 7 x 6 ft., completely equipped with motor, switch box and all electrical accessories, located in Phila. Several large plastic Mixers, both jacketed and unjacketed. Reply Box 626, Modern Plastics.

WANTED: 4 or 6 ounce injection molding machine. State age, type, condition; full particulars. Reply Box 627, Modern Plastics.

FOR SALE: 2—1200 gal. copper stills with 3″ steam heating coils, and tubular condensers. As good as new. 2—Aluminum jacketed tanks 52″ long x 39″ wide x 23″ deep inside measurements. Inside jackets ¼″ thick, outside jackets ⅛″ thick. Brighton Copper Works, 2159 Kindel Avenue, Cincinnati, Ohio.

WANTED: 4, 6, or 8 oz. Injection Molding Machine in good condition. Give full details. Reply to F. J. Kirk Molding Co., Clinton, Mass.

WANTED: Eight ounce injection moulding machines. Reed-Prentice type preferred. Give full details. Reply Box 629, Modern Plastics.

WHAT ARE YOUR POST-WAR PLANS FOR CANADA? Wide-awake distributor wishes to represent established company or to take Canadian sales franchise. Willing to build now for post-war future. Canada is a profitable market for plastic products. Excellent contacts in all fields including industrial, medical and novelty. Please give some information about your product. All letters held in strict confidence. Reply Box 630, Modern Plastics.

PLASTICS ENGINEER WANTED: By a Company long established in the plastics field. Applicant must have several years experience in Mould Design and Estimating for Compression and Injection Moulding. This vacancy may only be filled by a man possessing first class experience and ability, and who is accustomed to Customer Contact. Reply Box 636, Modern Plastics.

CHEMICAL ENGINEER: Unusual opportunity open with large and long established company having an extensive research and development program. Position is available for development work in plastics with this company which is not now engaged in plastics manufacture. The man desired must have a broad knowledge of the field. This is an unusual opportunity for a Chemical Engineer with the right technical qualifications and organizing ability. Inquiries will be held in strict confidence. Reply Box 628, Modern Plastics.

SALES REPRESENTATIVE WANTED: Experience in selling, liquid phenolic resins for coating, laminating, bonding, etc., to industries engaged in war work. Splendid opportunity for man who can develop volume sales. Reply Box 637, Modern Plastics.

WANTED: DRAFT-DEFERRED MAN with experience in plastics development and production, to develop and run new project in essential industry. Reply Box 641, Modern Plastics.

PRIVATE PARTY desires to buy good used plastic extruder, either National Rubber Machine No. 2½, John Royle machine No. 1 or No. 2, complete with motor 220 V 60 cycle AC, with or without conveyor system. Give particulars of machine and price wanted. Reply Box 631, Modern Plastics.

WANTED: COMB MOLDS—interested in all sizes and styles. Reply Box 644, Modern Plastics.

FOR SALE: Nine steam plates 48″ x 48″ x 2¼″ thick. American Insulator Corporation, New Freedom, Penna.

WANTED: 1—2 to 4 oz. H.P.M. or equal, injection molding press. Give details including price, condition, location, etc., when replying. Reply Box 632, Modern Plastics.

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WANTED: One Four-Ounce Reed-Prentice Injection Press. One National 2½ Inch Plastic Extruding Machine, in working condition. Reply Box 634, Modern Plastics.

WANTED—6″ Screw Type Extruder similar to Farrell-Birmingham or Royle, preferably with motor—Also 100 ton mechanical pre-form press with up to 4′ diameter cavity similar to Stokes or Kux-Lohner. Reply Box 642, Modern Plastics.

ASSOCIATION WITH ENTERPRISING MANUFACTURER of plastic products desired by sales executive, for mass production of patented, all plastic stirrup pump, plastic springs, and other patented non-competitive low priced personal accessory and industrial items. Continuous volume orders await production samples. Address Patent Owner, Box 639, Modern Plastics.

WANTED: INJECTION MOLDING PLANT either for outright purchase or will invest capital. Reply Box 643, Modern Plastics.

EQUIPMENT WANTED: Injection molding machine and compression molding machine, must be in good condition. Please reply immediately. Reply Box 645, Modern Plastics.

POSITION WANTED: Chemical Engineer completely familiar with injection and extrusion molding processes desires position as sales service man in field for aggressive company. Reply Box 638, Modern Plastics.

WANTED: Good used injection machine 8 ounce capacity. State age, make, condition and price. Reply Box 635, Modern Plastics.

MOULDER (plastic—injection) wanted, who can make mould and furnish materials and manufacturing facilities for a civilian health article in continuous large volume for a nationally prominent company. Will pay bonus for quick action. Reply Box 646, Modern Plastics.

WANTED: Injection molding machines—4 to 10 oz. capacity. Operating condition. Cash available for immediate delivery. Reply Box 648, Modern Plastics.

WANTED: Foreman for injection department of San Francisco firm. State experience, salary expected, when available, age, draft status, and references. Apply Box 647, Modern Plastics.

CHIEF CHEMIST: Position as chief chemist open to man with mature experience in the formulation and manufacture of phenolic laminating, impregnating and molding resins. Plant location in large industrial area in Middle West where opportunities in this field are unlimited. Quick availability important because of volume of War work. Only a qualified man with highest reference will be considered. State full details in reply addressed to Box 633, Modern Plastics.

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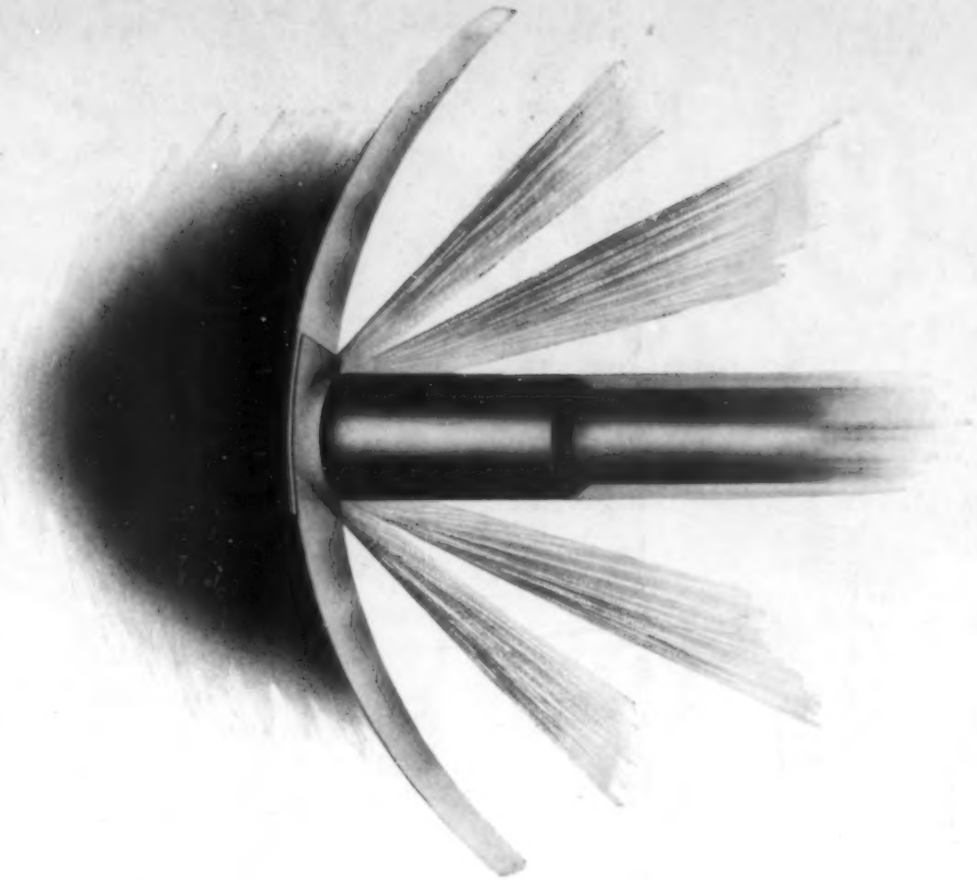

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The search for better adhesives is being stimulated by the war effort. All kinds of surfaces must be bonded together, and manufacturers are looking beyond the familiar bonds long supplied by nature and by industry . . . looking toward those brought forth by plastics research. . . adhesives based on synthetic resins. These new products are establishing new standards of bonding strength for the nation's essential needs.

Here, for example, is shown a special-purpose adhesive based on a VINYLITE resin—a modified polyvinyl acetate material—which is used as a bond between two pieces of steel. It has a higher tensile strength than most adhesives and is unusually resistant to impact. Yet, it provides more than just a *strong* bond. It will not deteriorate upon aging. It is colorless, odorless, tasteless, and non-toxic. Several variations are obtainable for bonding such diversified products as paper, glass, cloth, wood, and other materials.

As with other types of VINYLITE plastics, the wartime demand for this material has increasingly limited its use for commercial purposes. If you are engaged in war production, however, and are searching for adhesives with the unique combination of properties offered by those formulated with VINYLITE resins, be sure to request the services of our technical staff. VINYLITE plastics research may provide the answer to your problem.

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CARBIDE AND CARBON CHEMICALS CORPORATION
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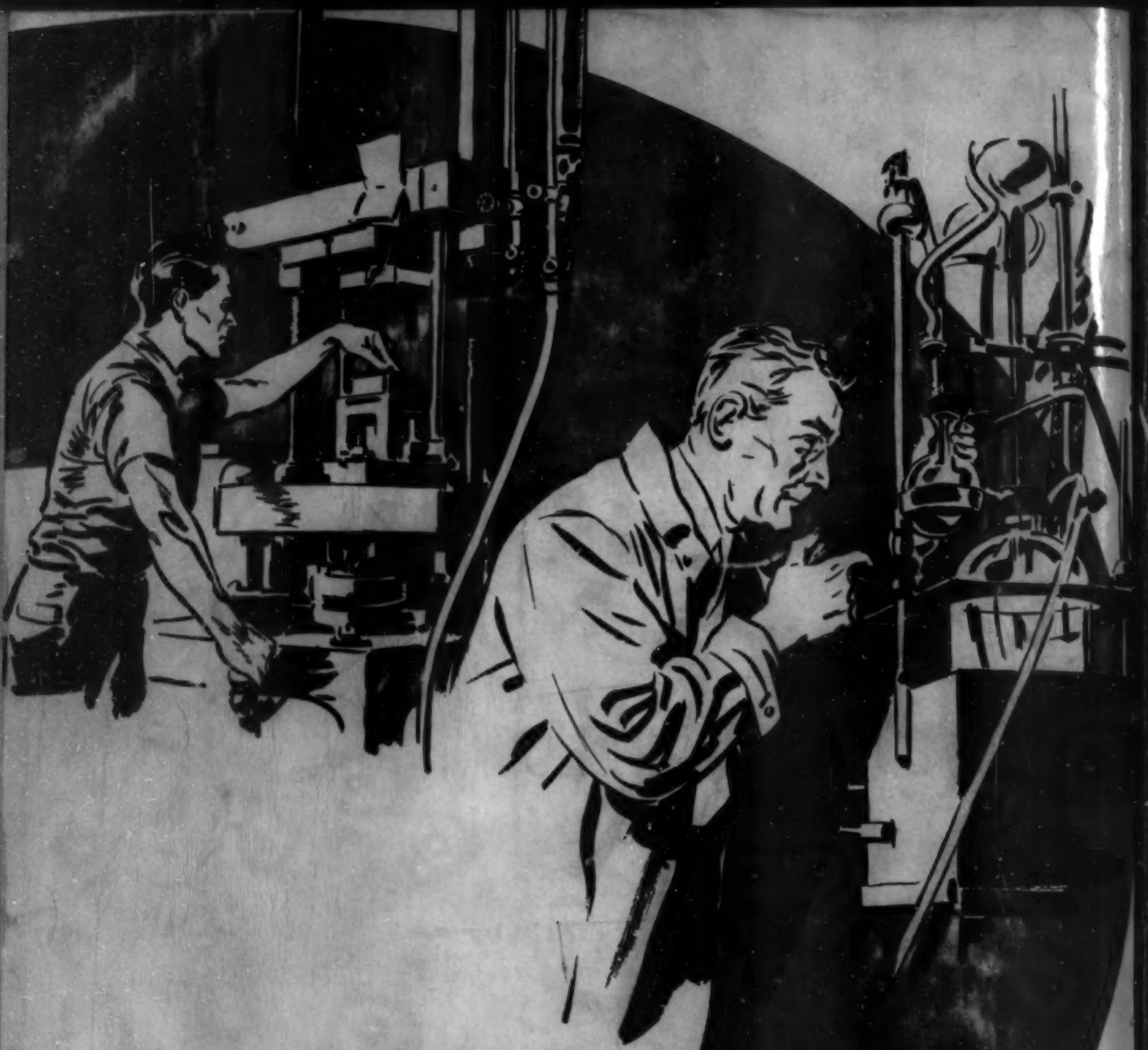

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